MANAGEMENT EDITION

THE Petroleum Engineer

Ninth Round-Up of World Oil Activities
Canadian Oil Hits a Hard Pace
Tapline: A Report by Aramco
Iraq's Baghdad Refinery

Exploration Drilling Producing — *Refining Petrochemical Gas Processing* — *Oil . . Gas Products Pipelining*

Your drill stem dollars go further with "flash-weld"

Comparative oil field records show that you get economy and maximum drill stem dependability when you buy Hughes "Flash-Weld" tool joints. They cost you less per foot of hole drilled. *Replacement is not necessary*—"Flash-Weld" tool joints last the life of the drill stem! The heavy wall section and the absence of pipe threads permit "Flash-Weld" joints to be safely rehardfaced in the field.

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APRIL 1956

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shuts out sand with plastic-coated walnut shells

SANDLOCK*, an exclusive new Dowell service, creates a permeable network of crushed walnut shells coated with plastic to control unconsolidated sand.

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IN THE FIRST PUMPING STATION of the Alaska Products Pipe Line at Haines, Alaska . . . as well as at Station No. 3, some 450 miles up the line at Tok Junction . . . Wilson-Snyder Quintuplex Plunger Pumps were selected because only reciprocating, positive-displacement pumps can handle both light and heavy liquids, at wide viscosity and pressure variations, in summer and winter temperatures, at uniformly high efficiency.

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MANAGEMENT EDITION

DRILLING AND PRODUCING EDITION

REFINING AND PETROCHEMICAL EDITION

OIL AND GAS PIPELINING EDITION

This Oil Boom Is World-Wide!

In 1955 a Belgian company found oil in a Portuguese territory in East Africa called Angola. A U. S. company developed the largest field in France, which it discovered in 1954. A British, U. S. and Australian combine counted up some $37 million expenditure exploring for oil in Papua without one paying well. A U. S. company was expanding its refinery in England, which is already the largest one there.

A German firm was drilling in Greece. A Dutch company was spending $40 million on a Venezuelan refinery. Guatemala, the Central American Republic which recently threw out a Communist regime, passed a petroleum law in August allowing outsiders to develop any oil they could find and over 30 companies filed applications and are expected to spend some $30 million exploring for oil.

While the search for oil went on, so did sales of oil products. Consumption was as buoyant as cash and credit could make it. The world wants more and more and more petroleum products. The U. S. consumed 8 per cent more in 1955 than in 1954. Demand of the rest of the free world probably went up 13 to 15 per cent though all the figures aren't in yet.

The world had an oil boom that saw not only so-called "international" companies but small companies and individuals of many nations exploring and developing and refining oil in most of the free world.

These new venturers into foreign oil sometimes combined into a larger firm and sometimes worked alone. Foreign operations are costly but rising expense in the U. S. and other well developed countries brought the costs almost in line.

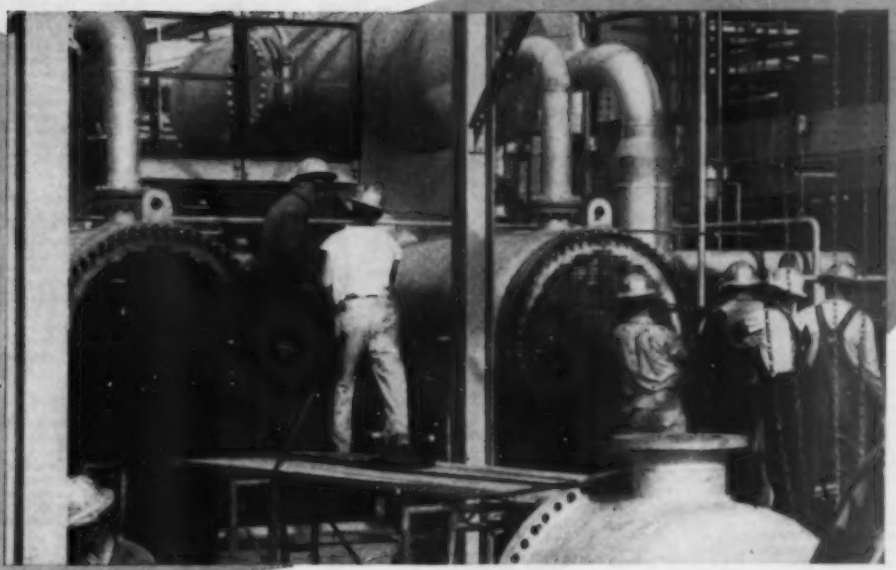
Trend of new laws was to be more reasonable toward foreign companies. The examples of Venezuela, Canada and other countries whose oil resources had brought riches without interference were beginning to break down some opposition to private capital. Countries that depended on state-owned monopolies to build up reserves were not having an easy time.

The world oil boom is a responsibility as well as an opportunity. Service to the country and to its citizens brings its own reward to the operator and through him, makes friends for his country. Both political entities and the petroleum industry are learning that wealth of resources is often a gift of mutual good will.

Ernestine Adams

Nalco TREATMENTS

can prevent plugging, put an end to costly turbining of heat exchanger tubes



Turbining operation means lots of downtime, lots of labor . . . two costly situations you can avoid with Nalco treatment.

WATER side plugging of heat exchanger tubes is an expensive nuisance Nalco has licked . . . and not on a *just-as-good* or *just-as-cheap* basis. Nalco treatment *often ends completely* the need for mechanical cleaning to remove sludge, scale, slime and corrosion products.

If plugged tubes plague your heat exchangers you can count on Nalco for substantial time and money savings. The Nalco System prevents sludge, scale, slime and corrosion...with chemicals and feeding procedures fitted exactly to your need by specialists in the water treating field.

Your Nalco Representative can give you an accurate picture of Nalco System possibilities for you. Call him, or write direct for prompt action.

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Nalco SYSTEM

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THROUGH PRACTICAL APPLIED SCIENCE

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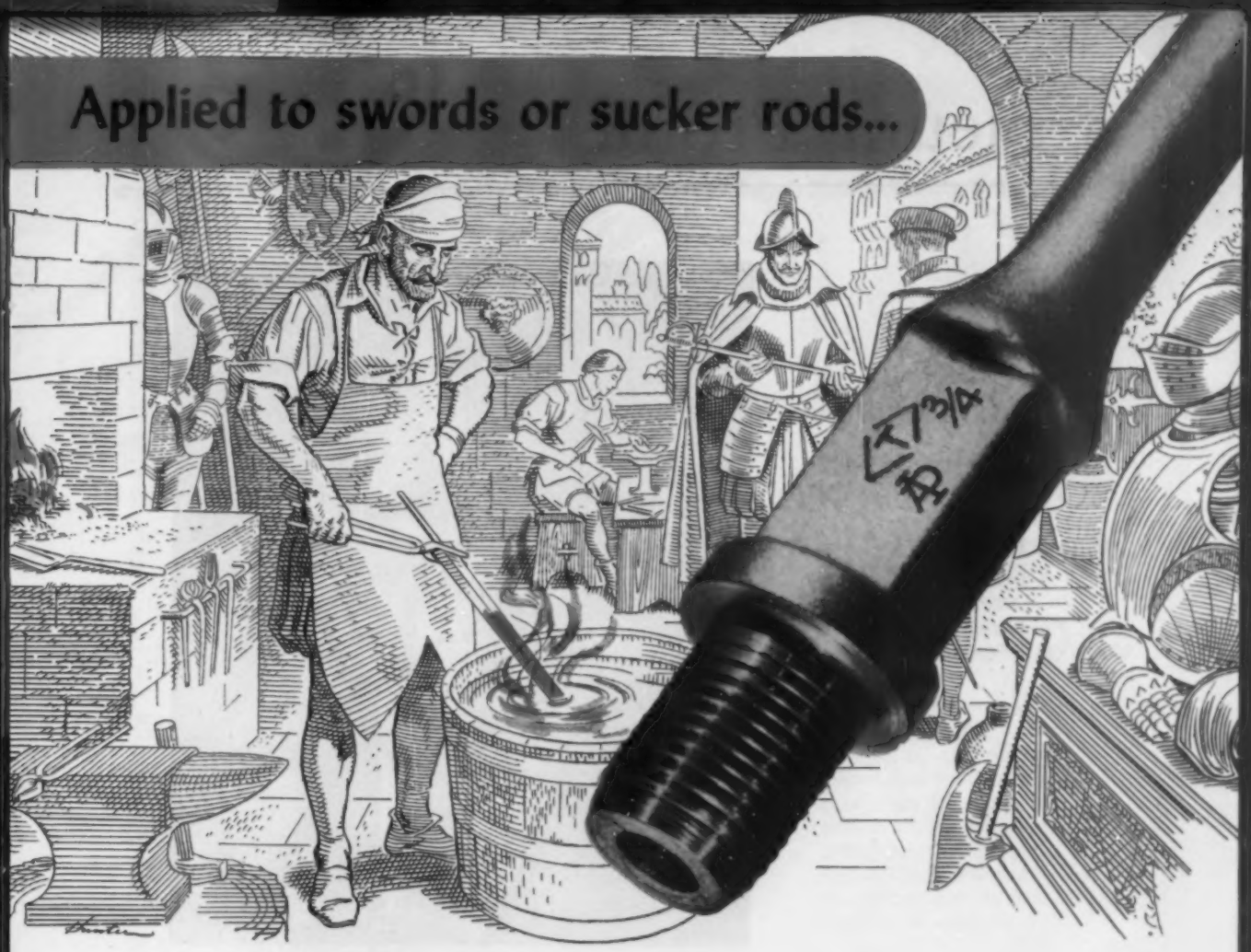
Applied to swords or sucker rods...



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The advantages of these extra heat-treating steps are shown in the Sucker Rod Comparison Chart which we will be glad to furnish without cost upon request . . . but they will become measurable when you run your own field test and compare the service liquid-quenched versus air-cooled rods will give in your own particular well. No slower cooling method approaches liquid quenching in capturing the grain structure which imparts optimum properties to alloy steels.

Variations in the chemical composition and alloy content of rod steels affects the service application as well as the price of finished sucker rods; but "Oilwell" gives you this extra heat-treating step in Grade "T," "W," and "Y" sucker rods at no extra cost. Run a string in your next well and learn how much the added strength, toughness and fatigue resistance of liquid-quenched rods can save you in operating costs.

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"OILWELL"

TRADE MARK

UNITED STATES STEEL

Petroleum Profile

R. O. RHOADES
Senior Vice President
In charge of
Production
Gulf Oil Corporation

R. O. RHOADES, senior vice president in charge of production for Gulf Oil Corporation, has been seeking oil and finding it for 30 years.

When he joined the company in 1926 as a geologist with its South American subsidiary, he already had behind him 6 years of experience as an oil geologist, including field work in Mexico and Egypt.

One of the first geologists in the Persian Gulf area, the Gulf Oil Corporation veteran did much of the geological work that led to the discovery of the fabulous oil fields in Kuwait. He also did the preliminary geological work in Bahrein which led to major discoveries there.

During the better part of two years with South American Gulf Oil Company, Rhoades was engaged in geological field work in Colombia, S. A. In 1927 he was transferred to Gulf Exploration Company for geological field work and other investigations pertaining to prospecting for oil in the Middle and Far East.

In 1933, Rhoades returned to this country to serve as a geologist in Gulf's Pittsburgh offices. In 1936 he was again transferred to Gulf Exploration Company for geological work in connection with prospecting for oil in the Middle East, Central Europe and the British Isles. Following approximately three years of field work, he served as a representative in the London office in England.

In 1940, Rhoades began his second tour of duty in Gulf Oil Corporation's Pittsburgh offices. During the following 10 years he served successively as geologist, assistant staff geologist, chief staff geologist and chief of the land and exploration branch. Appointment as executive assistant to the vice president in charge of production came in 1951.

During the same year he stepped up another rung of the ladder to vice president production department. Between 1953 and 1955 he served as vice president world wide production and exploration. He was designated senior vice president in charge of production in 1955.

Born July 30, 1895, in Urich, Henry County, Missouri, Rhoades matriculated at the University of Kansas in 1915. He left the University in 1917 to join the U. S. Marine Corps, and served with the Marine Corps in Europe from 1917 to 1919. He then resumed his studies at Stanford University, Stanford, California, where he received his B. A. degree.

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Performance — consistent, dependable, alert — has brought to our Petroleum Department outstanding producers who know we understand the problems of petroleum financing. In Republic's Oil Department, the first and most important question is always . . .

"WHAT CAN WE DO FOR YOU?"

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National **BANK** of Dallas

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

CAPITAL AND SURPLUS $70,000,000 • LARGEST IN THE SOUTH

Letters to and

What Does Make a Man Work?

We seem to have a lot of readers who were interested in "What Makes a Man Work." If you remember, Dr. A. Q. Sartain, psychologist and industrial relations consultant, discussed this topic in the March issue of *The Petroleum Engineer* (Page E-1).

A letter from W. F. Matheny, vice president and general manager of Sid Richardson Gasoline Company, Fort Worth, requested 50 reprints of the article. D. L. Fulshaw of Foster Wheeler Corporation and J. H. Marsee of Phillips Petroleum Company also asked for reprints.

J. R. Garrett of Flint Rig Company wrote the "article covered quite a bit of good sound information on the overall personnel problem that has confronted this nation for some time; especially, the engineering students in present day jobs. I would like very much to obtain a copy of the article for future reference as I have found it very interesting and would like to pass it on to my associates."

An important quality of Dr. Sartain's article is the fact that it covers all kinds of supervision from president of the company to foreman. Anybody interested in better industrial relations will benefit from it.

●

A letter that got a laugh out of the PE staff was the one that read, "Your magazine is so good that I think it is bad. So many good articles that I cannot keep up. All of vital interest. Congratulations, but my heavens!"

●

"A happy and productive life depends, first of all, on a healthy mind and body. And in matters of health as as in other human affairs, knowledge is a necessary step for greater fulfillment." So states the Richfield Oil Corporation booklet "Your Physician and You."

It is one of the most useful of this type informational booklet we have seen. Besides first aid, it gives a glossary of medical terms, also household measurements, Civil Defense instructions, world epidemiological map, routine immunization schedule and other useful items.

How to Learn From Reading

As a bow to Associated Business Publications, which celebrates its 50th anniversary this year, we reprinted "The Philosophy of Reading" (*The Petroleum Engineer*, March 1956, Page E-40). The author pointed out the importance and comparative ease of learning from reading.

Fifty years ago it was not thought so important nor was it so easy, to find informative reading. Professions and business and industry had a few "trade papers" and editors and publishers organized to exchange ideas and to work for more business-like policies. Problems were often similar in this type of publishing and members helped each other.

In the fast-moving, specialized world of today, could business and industry get along without their specialized publications? We would be crippled — not only by the actual slowing of communications but we would lose the feeling of belonging to a dynamic industry and thus lose some of the pride in our work.

Communications Technique

As you probably already know, we have been publishing a series of articles on Communications. We were reminded of this when we were reading about a new organization which is trying to improve technical communications. The organization already has 100 of the country's writing instructors, directors of technical publications, technical journal and trade magazine editors, engineers and company administrators. Chairman of the organizing committee is John L. Kent, chief of the editorial bureau of Consolidated Electrodynamics Corporation, Pasadena, California.

The object of "Technical Writing Improvement Society" is to improve the quality of technical papers and articles and to carry out research in communication of technical and scientific information. It looks like an idea that a lot of petroleum industry people would be interested in. If you are, you can write to John Kent and find out more.

●

Six out of every 10 American families own automobiles, and they spend an average of $325 a year to operate them, according to a study released by American Petroleum Institute.

Of that $325, roughly 60 per cent, or $200, is spent on service station items, such as gasoline, motor oil, tires, batteries, accessories and services. We don't doubt the API's figures but we don't know anyone who gets by on $325 a year per car.

●

A glossary on atomic energy has been released by Esso Research and Engineering Company. The booklet contains 101 frequently used terms which as simple definitions as can be written for technical words. If you're going to read articles like "Development of Atomic Energy" (*The Petroleum Engineer*, March 1956, Page E-13), it's a handy reference.

Government Oil Business

It has been reported that the Navy plans to ask Congress for $529,000 appropriation to use for wildcatting on San Nicolus Island, 60 miles offshore from Falbrook, California. As taxpayers we sincerely hope not. The Navy Petroleum Reserves record in finding and producing oil never showed much success. This couldn't be charged against the Navy so much as against the system of a government agency attempting to conduct one of the most complex operations in our economic system.

The Navy's operations in Alaska could have been as

From the Editor

well or better done by private companies and without costing the taxpayers $50 million.

The Administration can't reduce government in business by approving the Navy oil venture in the Pacific.

What's the Matter With Businessmen?

There is another investigation going on in Congress about businessmen in government. We've always argued that a little more business in government might be a salutory approach.

T. S. Petersen, president of Standard Oil Company of California, questioned the objection to businessmen in government when he spoke before the API last November. He said, "We hear it said, in effect, that attorneys can serve well and faithfully; that farmers can dispatch their government assignments with honor; that career civil servants and diplomats can be depended upon to uphold the public interest; that military men will be courageous and duty-bound.

"But businessmen, it seems, are not to be fully trusted. Unlike these other citizens whose loyalty is unquestioned, the businessman, it is alleged, cannot subordinate his private interests to those of the nation at large. The businessman, supposedly, ceases to be a first-class citizen when he becomes a businessman."

●

Another example of what automation has done came from the *American Magazine*:

"THE ICEMAN, contrary to popular opinion, is busier than ever today. Now supplying ice to industrial and commercial as well as domestic users, some 5000 ice plants across the country (as against 3500 in 1925) do an annual business of $325,000,000 as against $227,000,000 in 1935."

How to Influence People

When Admiral H. B. Miller, director of the Oil Industry Information Committee, spoke to the annual meeting of the Interstate Oil Compact Commission last December, he gave these points on how each person could help the oil industry in its public relations program.

1. Read our literature.
2. See our films.
3. Get acquainted with all sections of the industry.
4. Pass that information along to your employees and your families.
5. Encourage them to talk about oil to their friends, families and neighbors.

The idea is to bone up on information about such things as conservation practices, secondary recovery, well spacing, offshore drilling, and cracked gasoline. Then when you get a chance you can tell others how your industry works.

If you do plug for your industry, Admiral Miller says, and enough of you do it, oil will have millions of friends.

Unions: For Engineers?

Reprinted from the Missouri Shamrock

Recently we have received some literature on the subject of unions for engineers. Apparently quite a bit of this type of material is being mailed to colleges in the hopes of swaying the student of engineering in favor of engineering unions. One letter in particular was quite interesting to us; it was an excellent example of techniques used in all sorts of organizing campaigns. At one point is said "... over 40,000 of the country's engineers and scientists currently enjoy the economic and professional advantages of collective bargaining."

This is the old "jump on the bandwagon, everybody's doing it" technique. Unfortunately, the letter failed to state just what are the advantages of collective bargaining *for engineers*. The writer of the letter signed it "Fraternally yours ..."; and after his name listed his college, year of graduation and three Greek letters, apparently a social fraternity to which he belonged. In the body of the letter it was stated that many of the officers of this particular union were former fraternity men. The letter further stated that "it is planned to mail material at regular intervals to the various social fraternities." This all adds up to another well worn organizing technique — identifying yourself with your audience.

We are somewhat curious as to what the logic is in choosing a social fraternity as the prime target for union literature. Most of the social fraternities have a pretty good sampling of students from every branch of learning. Material mailed to them will reach a relatively small segment of the engineering enrollment. This is unfortunate, inasmuch as the union literature is one of the most convincing arguments in favor of *not* joining an engineering union.

One thing which is usually lacking in union literature but is much in evidence in union contracts is the word "seniority." This single word represents one of the most significant and destructive concepts in our society. It is a poor substitute for initiative, ability and hard work.

In many industrial organizations, management has resorted to incentive payments for union workers who no longer have any competitive spirit; it is interesting to speculate on how they would contrive to "induce" a competitive spirit in the unionized engineer.

America is currently in the grip of a shortage of engineers. The shortage, according to Ass't. Sec'y. of Defense Donald Quarles constitutes "potentially a greater threat to national security than any aggressor weapons known." (November 1955 TIME magazine.) The surest way to make this shortage more acute, and to jeopardize American freedoms, is to eliminate the "American system" of competition in the professions and to unionize the Engineers. P.D.G.

●

Annual financial reports are beginning to come out and promise to be interesting both in content and format. Two Dallas banks get our prize so far — Republic National has some of the most beautiful color photos we have seen and First National added a new and attractive novelty — two excellent articles by outside writers.

The old annual report ain't what it used to be either in looks or in the financial picture it presents. Watch for annual reports survey next month.

HIGHLIGHTS

★ ★ ★

Digest of News and Comment

Refiners have tentatively been granted excise tax relief by a House Ways and Means subcommittee. The approved change affects the tax on transportation of oil by pipe line, in that such a levy should not apply to any movement which constitutes an integral part of the operation of a refinery, bulk plant, terminal or gasoline plant. Present law puts a 4½ per cent tax on the charge of transporting oil by pipe line, but exempts movements through lines on the premises of a refinery.

★ ★ ★

Traffic volume and toll revenue on asphalt turnpikes are running years ahead of engineering forecasts, the Asphalt Institute reports. The asphalt toll roads are showing a solid record of earnings while establishing substantial operating reserves. Noteworthy success is the 118-mile New Jersey Turnpike, which shows a net revenue of nearly $39,500,000 while carrying some 90,992,781 vehicles without structural failure in the pavement.

★ ★ ★

Independent producers will file some 1000 applications for operating "convenience and necessity" certificates, FPC officials predict in the face of rumors that new interstate gas sales would decline because of continued government control. Chairman Kuykendall told a House Appropriations subcommittee the FPC can expect 1000 applications in the coming fiscal year beginning in July — in addition to the 4000 already on file.

★ ★ ★

"Greater knowledge — greater service," has been adopted as the theme of the fifth annual convention of Desk and Derrick Clubs of North America. The meetings will be held September 7-8 in New Orleans, Louisiana. An attendance of 1500 to 2000 members is expected from the 108 clubs which make up the organization.

★ ★ ★

Tax depletion allowance is getting another congressional threshing in the form of a bill proposed by senators Williams of Deleware, Aiken of Vermont, Smith of Maine and Purtell of Connecticut. The new bill would shrink the tax allowance of 27½ per cent to 15 per cent. Williams claims the allowance is three times as valuable today as when the rate was established. Williams should be reminded that industry oil development costs have gone up more than three times.

★ ★ ★

Farmers will get natural gas for irrigation purposes, an action which the Phillips Petroleum Company has claimed unconstitutional. Phillips, which had already contracted for the sale of its gas in the Oklahoma Panhandle area, was ordered to sell to farmers at prices set by the State Corporation Commission. A State Supreme Court denied the company's application to assume original jurisdiction; previously the U.S. Supreme Court had ruled against Phillips.

★ ★ ★

Research laboratory of Carter Oil Company, Tulsa, Oklahoma, will be increased in size and employees through the addition of a new two-story building. The new structure, adding some 25,000 sq ft of floor space, is tied to the building. Twenty-two lab rooms and 43 offices will be housed in the new addition, and will bring the Carter research force in Tulsa to 275 people. All phases of research will benefit from the new facilities.

★ ★ ★

Crude oil production in the U. S. declined 1.8 per cent in 1954 from the record level in 1953, final summary of the Bureau of Mines reports. Although large gains were listed in Colorado, Wyoming, Illinois, Kansas and New Mexico, declines were seen in major-producing states of Texas, Louisiana and California. The decline was related to reduction in new crude due to a 16,300,000 bbl domestic crude stock during the year.

★ ★ ★

Potent gasoline may come in the form of an alcohol additive. An amendment to the Farm Bill has been proposed by 19 senators calling for increased use of industrial alcohol made from grain, now made principally from imported molasses and petroleum. A senate leader hinted that tax powers might be used to force use of "alkygas," utilizing a 5 per cent blend of alcohol, using a billion bushels of grain.

Home state use of natural gas is getting support of major companies. Phillips Petroleum Company, for one, has advanced a plan to use large quantities of its large gas reserve in Texas to supply a gigantic chemical and petrochemical center near Houston. The firm purchased a 950-acre tract in the Houston ship channel industrial area to be developed by individual companies. State leaders, such as E. O. Thompson of Texas (where nearly 50 per cent of the nation's gas is produced), are urging Texans to seek industries to use the gas "right here at home within our own borders."

★ ★ ★

All-time stainless and heat-resisting steel production highs last year, reflecting a general rise in business activity, increased 40 per cent over 1954. Production for 1955 was 1,191,177 net ingot tons, compared to 852,021 net tons the previous year.

★ ★ ★

Antitrust division chairman, Justice Department, Assistant Attorney General Stanley N. Barnes, has failed to endorse a House subcommittee report on petroleum groups. The historical review, prepared for the judiciary antitrust subcommittee of Congressman Celler, attempted to show that the API was formed after World War I to "perpetrate" a monopoly. Barnes, who has appeared twice before Celler's group, feels that industry-staffed advisory committees can help the government if it would be in agreement with Department of Justice policy.

★ ★ ★

Sales or gasoline taxes gave three-fourths of the 48 states their major source of revenue during 1955. General sales and use taxes provided 23 states with the largest share of revenue, while motor fuel taxes led the way in 14 states. Texas and Louisiana got their major share from levies on oil and other mineral wealth.

★ ★ ★

Navy plans for drilling on San Nicholas Island, some 60 miles off the California coast, will indeed produce much information to West Coast geologists, even if no oil is found. U. S. Geological Survey has reported that drilling prospects are favorable. The Navy plans to spend some $529,000 on the exploratory project, the first such venture on land not a part of a Naval Petroleum Reserve.

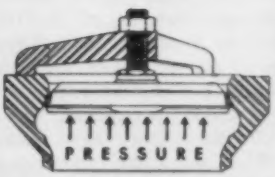
It's no effort at all to reach the internals of this Peerless Gas Odorizer through the Sillers Flex-Ring Closure.

Sillers Flex Ring Closures are utilized on these large scrubbers at a Field Processing Plant in South Texas.

Here is a typical Sillers Flex Ring Closure installation on a Sillers Scraper trap, on a products pipeline in Eastern Oklahoma.

SILLERS FLEX RING CLOSURE

for faster access to the inside of pressure vessels or piping . . .



(1). Flex Ring Unit assembled as in service. (2). Spider released, gasket being removed. (3). After gasket is removed, plug is rotated to open. (4). Unit completely opened and in a fraction of time taken for conventional type closures.

SIMPLE and SAFE to OPERATE...

An entirely new design and seal principle, the SILLERS FLEX RING CLOSURE gives you many advantages and economies such as LOW INITIAL COST . . . LESS TIME IN OPENING AND CLOSING (JUST ONE BOLT) . . . TIGHTER SEAL AT HIGH PRESSURES . . . LESS WEIGHT . . . EASE OF HANDLING . . . and NO SEAL DESTRUCTION IN CASE OF FIRE. Sillers Flex Ring Closures are available in all standard sizes and can quickly be adapted for special applications.

GET COMPLETE DETAILS TODAY
SEND FOR BULLETIN NO. 3000

The perfect closure for Boilers, Evaportors, Heat Exchangers, Autoclaves, Filters, Strainers, Absorbers and all types of Pressure Vessels and Piping Systems.

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SILLERS ENGINEERING COMPANY

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BOX 13165 DALLAS, TEXAS

Representatives in Principal Cities

Direct government subsidies to oil companies, rather than the depletion allowance, would be given to provide incentive to drill wells — if a new House bill by Congressman Reuss of Wisconsin is passed. The bill is another attempt to kill the industry's 27½ per cent depletion allowance, that Reuss says enables oilmen to "spend political money like a drunken sailor."

★ ★ ★

American companies produced more than half of last year's 162,000,000 ton oil output in the Middle East, a recent report reveals. American companies accounted for 87,000,000 tons; British and Dutch interests together produced 48,500,000 tons. Most of the oil from this area was produced in Kuwait (54,000,000 tons), Saudi Arabia (47,600,000 tons) and Iraq (33,700,000 tons).

★ ★ ★

Market for domestic crude oil in April and May will slump some 400,000 bbl daily, forecasts the Independent Petroleum Association of America. The group cites a seasonal drop in demand, recent high supply levels, scheduled increases in crude oil imports, and increasing stocks as "primary factors pointing to reduced market for domestic crude oil."

Domestic oil production may soon reach its peak, a story that has been heard many times before, is being predicted by M. King Hubbert, Shell Development Company economist-geologist. Hubert claims that top production will be reached within the next 10 or 15 years, and declares that a deficit "already exists between domestic consumption and production of oil and its products, and this deficit is being made up by imports which already amount to about 20 per cent of domestic production and are continuously increasing."

★ ★ ★

Additional price hikes of Penn grade crudes, higher prices of steel products and other gradual increases have brought members of the Texas Independent Producers and Royalty Owners to ask purchasers for an immediate 20 per cent increase in the price of crude. Spokesmen for the group cite that oil prices have averaged about $2.77 per barrel since the last general increase in 1953, while drilling and equipment costs have increased as much as 50 per cent in some areas. Several oilmen, fearing more government intervention, have suggested that the time is not yet right to ask for a crude price hike.

Attending the dedication of Australia's largest oil refinery were: Mrs. A. R. G. Hawke; Senator Dorothy Tangney; Lord Strathalmond, recently resigned chairman of the board of BP; Mrs. D. W. Brisbane, wife of the chairman of Australasian Petroleum Refining Ltd.; Warren Smith, president of The M. W. Kellogg Company; Lady Strathalmond; and A. R. G. Hawke, Premier of Western Australia. The integrated 60,000 b/d plant at Kwinana, designed and built by Kellogg, was completed three months ahead of schedule.

Motion picture films made by British Petroleum Company are receiving special commendation, with showings of the top three of the most recent groups scheduled in London for stockholders and guests of the company. BP plans a repeat performance of a similar showing in 1952, when audiences totalling 12,000 saw BP films simultaneously.

★ ★ ★

Half of the domestic crude production will come from waterflood operations in days not far distant, predicted Tulsa oil consultant H. H. Kaveler before a recent meeting of the Rocky Mountain and Mid-Continent section of the Petroleum Equipment Suppliers Association. Some 20 per cent of current domestic production is due to pressure maintenance operations, with more than 3000 projects now in progress in the country.

★ ★ ★

Government control of natural gas is now complete from the wellhead to the burner-tip. FPC has affirmed an examiner's decision denying Northern Natural Gas Company's plan to build pipeline facilities to supply the Black Dog power station of Northern States Power Company, near Minneapolis, Minnesota. The commission asserted that it had repeatedly held that the use of natural gas as a boiler fuel was an inferior usage and it should only be permitted when required by "public convenience and necessity."

★ ★ ★

The "Big Five" oil producing states — Texas, California, Louisiana, Oklahoma, and Wyoming — held 84 per cent of the nation's crude reserves in 1955, the same figures as in 1954, ccording to American Petroleum Intitute estimates.

Total oil reserves at the end of 1955 was 30.012 trillion bbl — about 451,000.000 bbl more than a year earlier. "Big Five" natural gas states are Texas, Louisiana, New Mexico, Kansas and Oklahoma, holding 84 per cent of the nation's reserves.

★ ★ ★

Recent natural gas litigation has given rise to a new type of business organization designed to give gas producers an economic and engineering service, with respect to principles and methods of the FPC. Foster and Associates, Washington, D. C., has been formed by men who prepared much of the data used in the Harris-Fulbright proceedings.

Dowell's paddle mixing equipment supplies a constant flow of properly mixed materials to the large-volume pumps.

FRACTURE AND ACIDIZE IN ONE ECONOMICAL TREATMENT!

ACID PETROFRAC* is an exclusive Dowell fracturing treatment with double action for better results with less rig time. It uses an acid-in-oil emulsion to fracture and acidize in one operation. Acid constitutes 90 to 95% by volume of the total mixture. The oil phase may be kerosene, diesel oil or crude oil.

Its high acid content with retarded acid properties means deeper penetration, extended drainage pattern and increased permeability. Sand carrying ability is high, up to 6 pounds per gallon—even at high temperatures.

Dowell engineers tailor each Acid Petrofrac treatment to fit your well requirements. Fluids can be premixed or prepared at the well site in Dowell's paddle mixing equipment. The mixture can be regulated to obtain the proper viscosities and fluid loss. Properties which prevent the swelling of silicates in the spent acid solution are inherent in Acid Petrofrac. No gel-breaker is needed. No shut-in time is required.

For more information or service, call any of the 165 Dowell offices in the United States and Canada; in Venezuela, contact United Oilwell Service. Or write to Dowell Incorporated, Tulsa 1, Oklahoma, Department D-12.

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services for the oil industry

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Selecting A Motor Drive For A Hazardous Area?

Here's how

TEIGF motors

by E-M

provide safe, dependable, economical power

Faced with the problem of driving hydrogen compressors in atmospheres which might contain hydrocarbons at their Baltimore refinery, engineers of Esso Standard Oil Company turned to TEIGF (Totally Enclosed Inert Gas Filled) Motors. Horsepower requirements exceeded the practicable limits under which explosion-proof motors could be used.

An important consideration was getting the greatest possible drive economy while operating safely in a possible hydrogen atmosphere. Three E-M 350 hp, 390 rpm TEIGF Motors are on duty at Esso Standard Oil Company fulfilling these important qualifications.

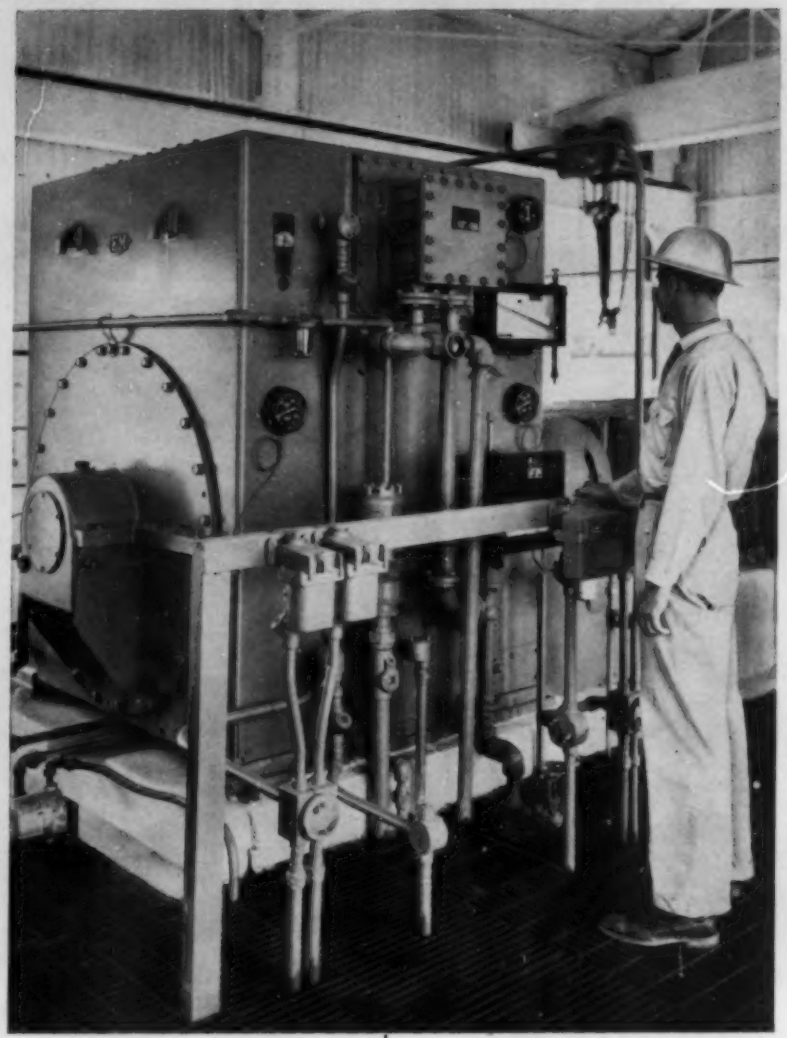
For Esso Standard Oil Company and other companies with similar problems, these E-M Motors offer three main groups of advantages:

1. SAFETY — Within the motor enclosure, inert gas pressure above atmospheric keeps explosive hydrogen *out*. A series of features help accomplish complete safety . . . inert gas pressure gauges . . . temperature gauges . . . purging valves, etc. and a full line of optional equipment. The E-M TEIGF Motor can be "customized" to meet your needs exactly.

2. RUGGED DEPENDABILITY. E-M uses specially designed "box type" frames of heavy-duty plate steel reinforced with heavy bar-stock ribs. They cannot twist or distort. Air gap is accurate and permanent, as all frame welding is completed before precision boring. Ventilating gas passages are carefully engineered to provide unimpeded gas flow for optimum cooling.

3. ECONOMICAL OPERATION. In E-M TEIGF Motors, gas loss is lower than commercially accepted standards. Specially designed shaft seals are oil-pressure gas-sealed bearing type, virtually non-wearing. Where bolts enter outside casing, E-M engineers specify blind holes . . . tapping and drilling are done *into* casing, not through. Operating and maintenance costs are at a minimum.

Consult your nearest E-M sales engineer, or write the factory for TEIGF Motor Bulletin No. 226.



TYPICAL STANDARD FEATURES INCLUDE:

1. Top-mounted gas-to-water cooler for use with suitable cooling water supply.
2. Forced-feed lubricated bearings and oil-pressure gas seals.
3. Oil pump, motor and oil filter. (Can be supplied optionally inside enclosure.)
4. Inert-gas temperature gauge.
5. Inert-gas pressure gauge.

(additional features shown in Bulletin No. 226)

TYPICAL OPTIONAL FEATURES INCLUDE:

1. Water cooler with double-tube construction for added protection against leakage.
2. Liquid level detector switch. Accumulation of moisture within motor sounds alarm or shuts down motor.
3. Bearing temperature relays, to sound alarm or shut down motor.
4. Explosion-proof motor terminal pothead or inert-gas filled terminal box.
5. Water flow indicator. Can be adapted for use with pneumatic-type regulating device.

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EXACTLY WHAT YOU WANT THEM TO

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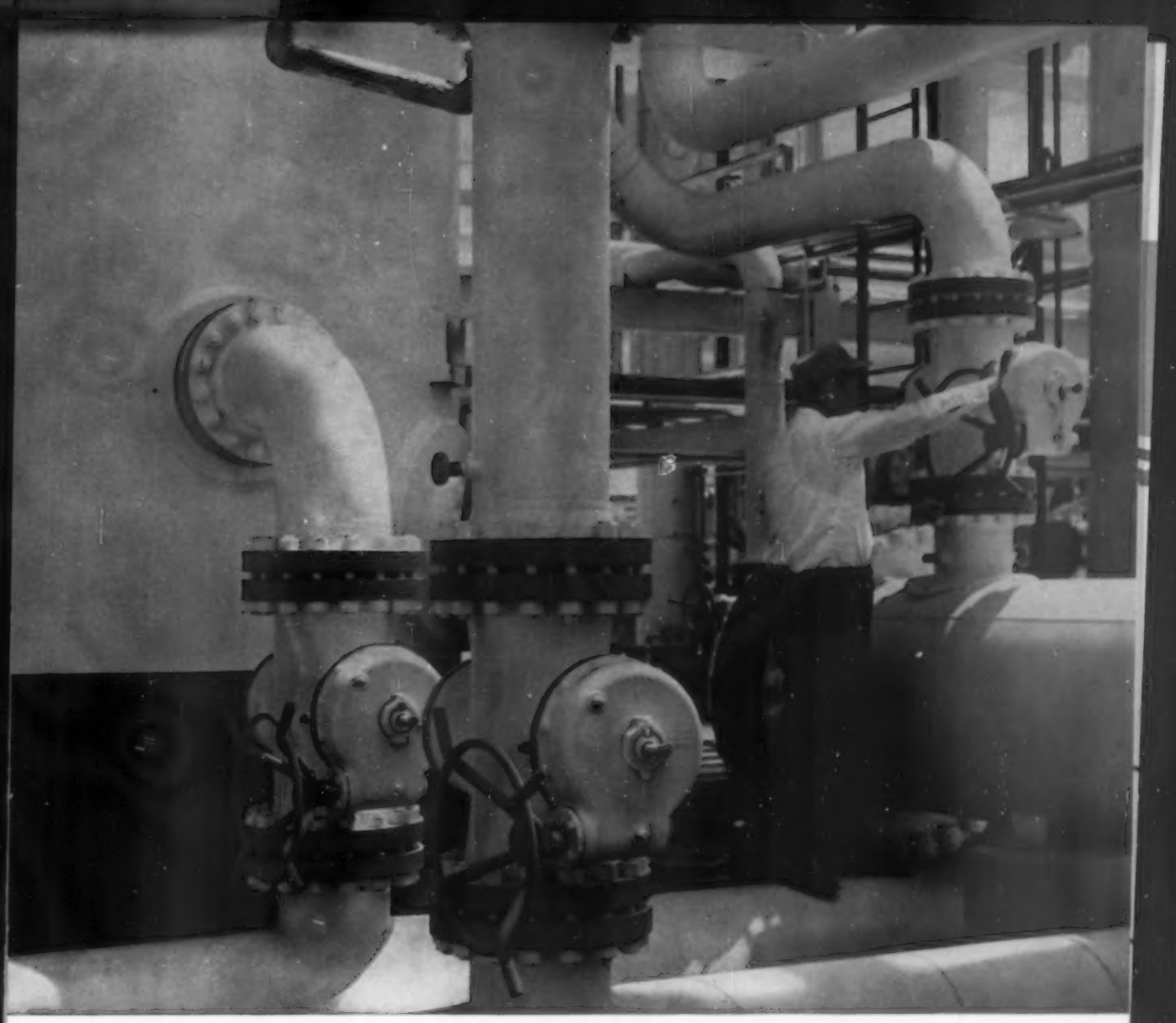


Why gamble your profits?

Valves are a major investment. Why gamble your profits on risky valves when you can buy the best at a price that is often lower than ordinary valves? Your valve investments are secure when you specify Rockwell-Nordstrom valves because *pressurized lubrication* assures economy and dependability in these three important ways:

1. Leakproof Sealing . . . eliminates uncertain, "forced" metal-to-metal seating.

2. Longer Life . . . lubricant stops trouble before it starts . . . slashes repair, maintenance and down time costs.

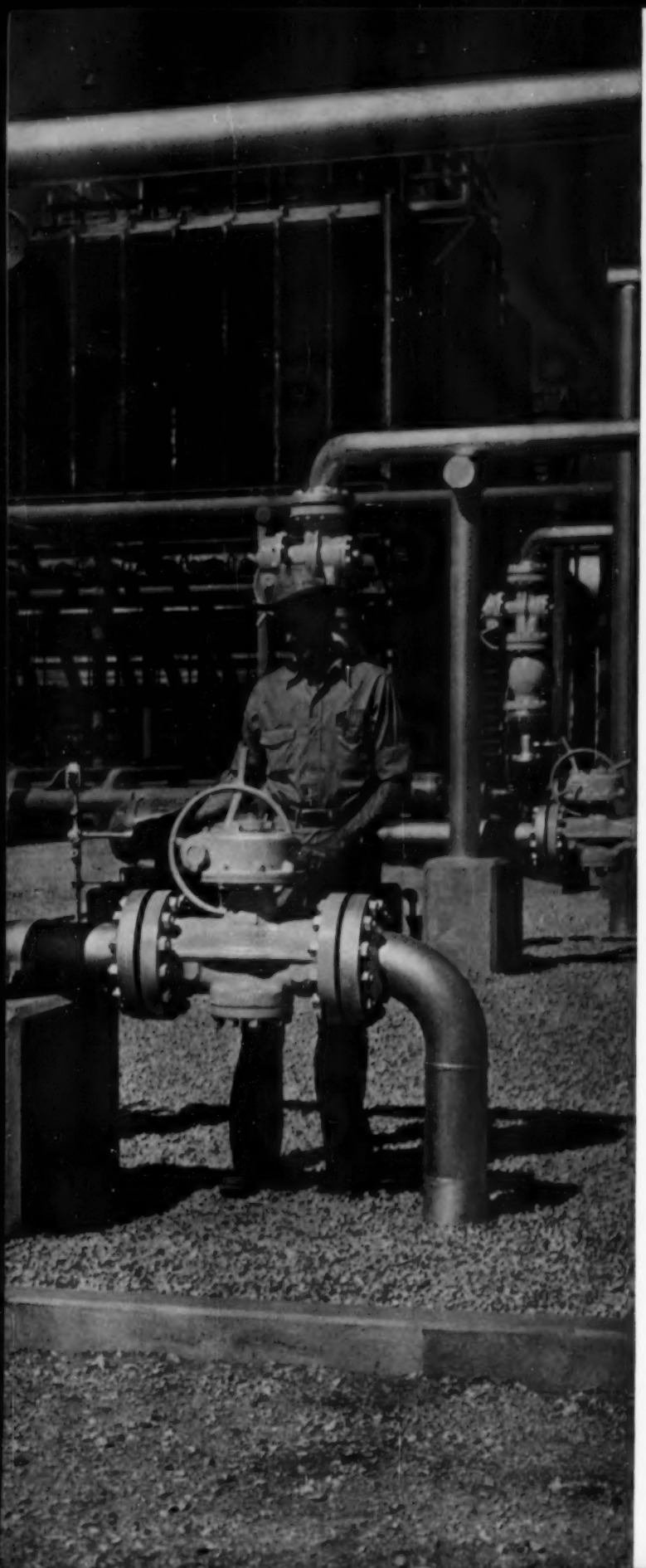
3. Instant Operation . . . lubricant "cushions" plug for smooth, quarter-turn operation.

Forty years of lubricated plug valve leadership by the original and world's largest manufacturer is your assurance of economy and trouble-free dependability when you specify Rockwell-Nordstrom valves. Rockwell Manufacturing Company, Pittsburgh 8, Pa.

ROCKWELL-Nordstrom VALVES

Lubricant Sealed for Positive Shut-off

40th Year *of lubricated plug valve leadership*



How to handle tough services

Many services (like high-velocity gas service) eat the heart right out of ordinary valves. Metal-to-metal seating soon becomes pitted or scored and the valve won't hold. The result—expensive reseating, down time and snarled production schedules.

In Rockwell-Nordstrom valves a thin, tough film of pressurized lubricant between the plug and the valve body forms a *continuous* and *dependable* seal at any pressure on any service. The lubricant also protects against corrosive-erosive material and eliminates metal-to-metal friction for longer service life at lowest cost.

Rockwell-Nordstrom, *the original and most complete line* of lubricated plug valves are available in steel, semi-steel, stainless steel and special alloys for a complete range of pressures and temperatures. For more information, write: Rockwell Manufacturing Company, Pittsburgh 8, Pennsylvania.

Available at leading suppliers . . . everywhere.

ROCKWELL-
Nordstrom
VALVES

Lubricant Sealed for Positive Shut-off

40th Year
of lubricated plug valve leadership

Meetings

April 11-13—**Natural Gasoline Association of America,** annual, Texas Hotel, Fort Worth, Texas.

April 14-19—**Petroleum Equipment Suppliers Association,** Boca Raton, Florida.

April 15-17—**Texas Independent Producers and Royalty Owners Association,** Statler Hilton Hotel, Dallas, Texas.

April 18-20—**National Petroleum Association,** semi-annual meeting, Cleveland Hotel, Cleveland, Ohio.

April 18-20—**American Petroleum Institute,** Division of Production, Rocky Mountain district, Cosmopolitan Hotel, Denver, Colorado.

April 19-20—**West Texas Oil Lifting Short Course,** annual, Texas Technological College, Lubbock, Texas.

April 19-21—**Indiana Gas Association,** French Lick Springs Hotel, French Lick, Indiana.

April 23-25—**Southern Gas Association,** convention, annual, Statler Hilton Hotel, Dallas, Texas.

April 23-26—**American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists,** annual meeting, Conrad Hilton Hotel, Chicago, Illinois.

April 25-27—**American Petroleum Institute,** Division of Production, Eastern district, Statler Hotel, Deshler-Hilton Hotel, Columbus, Ohio.

April 25-29—**World-Oil Exposition,** Houston, Texas.

April 26-27—**American Institute of Electrical Engineers,** national meeting, Bradford Hotel, Boston, Massachusetts.

May 1-3—**Petroleum Industry Electrical Association and Electrical Suppliers Association,** annual conference and exhibits, Statler Hilton Hotel, Dallas, Texas.

May 4—**Annual Conference for Engineers,** Ohio State University, Ohio Union, Columbus, Ohio.

May 6-9—**Liquefied Petroleum Gas Association,** convention and show, Conrad Hilton Hotel, Chicago, Illinois.

May 6-9—**American Institute of Chemical Engineers,** Roosevelt Hotel, New Orleans, Louisiana.

May 7-8—**Gas Compressors Institute,** Randall Cafeteria, Liberal, Kansas. Sponsored by University of Kansas and Southwest Kansas Petroleum Industry.

May 10-11—**American Gas Association** gas supply, transmission and storage conference, Conrad Hilton Hotel, Chicago, Illinois.

May 10-11—**American Petroleum Institute,** Division of Production, Pacific Coast district, Statler Hotel, Los Angeles, California.

May 14-15—**American Institute of Mining and Metallurgical Engineers,** Formation Fracturing Symposium, Wichita, Kansas.

May 14-16—**American Petroleum Institute,** Pipe Line conference, Shamrock Hotel, Houston, Texas.

May 14-16—**Petroleum Electric Power Association,** 27th annual meeting, Driscoll Hotel, Corpus Christi, Texas.

May 14-17—**American Petroleum Institute,** Division of Refining, midyear meeting, Montreal, Canada.

May 15-17—**Purdue Industrial Waste Conference,** Purdue Memorial Union, Lafayette, Indiana.

MANZEL

VACUUM SIGHT FEEDS Eliminate Your Need For X-Ray Eyes!

The sight feeds on vacuum pumping models of Manzel Force Feed Lubricators can't cloud or fog. They're always clean and clear — and king size. Long rows can be checked at a glance. Even light-colored lubricants are clearly visible.

Manzel Vacuum Pumping units are time-tested and proven in daily use throughout the oil industry. They're being hailed as the best answer to the low visibility and high maintenance costs of liquid sight feeds. For the complete story, wire or write.

SPECIAL QUALITY FEATURES OF MANZEL LUBRICATORS

- Completely protected with Parco Lubrite
- Rust resistant reservoirs
- Closer fitting plungers made possible by special precision equipment
- Gears of harder alloy for longer wear
- Every unit factory-tested before shipment

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Do you have this informative 20-page buyers' guide on pumps?

If you specify or purchase oilfield equipment, you will want to have on file this recently published catalog. Featuring all the many models of Gorman-Rupp Pumps useful to this important field, it contains specifications, performance data, cutaway views and application information. A copy will be sent you on receipt of the coupon below, by our Mid-Continent & Gulf Coast Oilfield Representative.

CONTENTS OF CATALOG

Self-Priming Centrifugal Pumps for
- DRAINAGE or WATER SUPPLY
- GENERAL UTILITY (Lightweight)
- PETROLEUM PRODUCTS
- JETTING, DRILLING, FIRE PROTECTION, MUD or SLURRY HANDLING
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Gorman-Rupp PUMPS

May 17-18—**Rocky Mountain Petroleum Sections of American Institute of Mining and Metallurgical Engineers,** Gladstone Hotel, Casper, Wyoming.

May 17-18—**American Institute of Mining and Metallurgical Engineers,** joint meeting of Rocky Mountain Petroleum Sections, Gladstone Hotel, Casper, Wyoming.

May 22-24—**Pennsylvania Gas Association,** Pocono Manor Inn, Pocono Manor, Pennsylvania.

May 24-25—**Natural Gas and Petroleum Association of Canada,** Sheraton Brock Hotel, Niagara Fal's, Ontario, Canada.

May 30-June 1—**Short Course in Gas Technology,** annual, Texas College of Arts and Industries, Kingsville, Texas.

May 31-June 2—**Interstate Oil Compact Commission,** mid-year meeting, Statler Hilton Hotel, Dallas, Texas.

June 11-12-13—**Appalachian Underground Corrosion Short Course,** annual, School of Mines of West Virginia University, Morgantown, West Virginia.

June 17-22—**Creative Engineering Seminar,** The Pennsylvania State University, University Park, Pennsylvania.

June 17-22—**American Society for Testing Materials,** Pacific Coast meeting, Hotel Statler, Los Angeles, California.

June 21-22—**Western Petroleum Refiners Association Regional Technical-Industrial Relations meeting,** Broadview Hotel, Wichita, Kansas.

June 25-29—**The American Society for Engineering Education,** annual meeting, Iowa State College, Ames, Iowa.

June 26-29—**Canadian Gas Association,** Manoir Richelieu, Murray Bay, Quebec, Canada.

Sept. 9-12—**American Institute of Chemical Engineers,** William Penn Hotel, Pittsburgh, Pennsylvania.

Sept. 10-14—**International Congress on Catalysts,** Bellevue-Stratford Hotel, Philadelphia, Pennsylvania.

Sept. 11-13—**Pacific Coast Gas Association,** annual meeting, Coronado, California.

Sept. 12-14—**Third Annual Electrical Conference of the Petroleum Industry,** sponsored by American Institute of Electrical Engineers and Kansas City Section of AIEE, Kansas City, Missouri.

Sept. 16-22—**American Society for Testing Materials,** Pacific Coast meeting, Hotel Statler, Los Angeles, California.

Sept. 17-21—**Instrument Society of America,** annual, Instrument-Automation Conference and Exhibit (International), New York Coliseum, New York City.

September 20-21—**Western Petroleum Refiners Association Regional Technical-Industrial Relations,** Hotel Henning, Casper, Wyoming.

Oct. 1-5—**American Institute of Electrical Engineers,** Morrison Hotel, Chicago, Illinois.

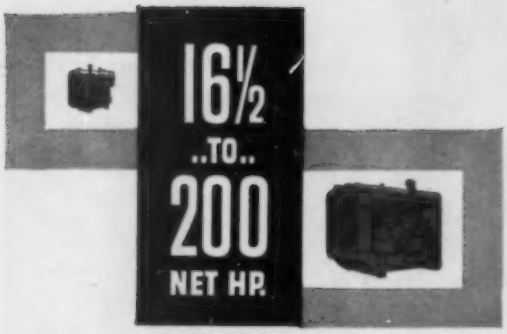
October 14-17—**Petroleum Branch Fall Meeting, American Institute of Mining and Metallurgical Engineers,** Biltmore Hotel, Los Angeles, California.

Week of October 15—**American Gas Association** annual convention, Atlantic City, New Jersey.

November 19-20—**North Texas Section of American Institute of Mining and Metallurgical Engineers,** Symposium on Secondary Recovery, Municipal Auditorium, Wichita Falls, Texas.

Nov. 25-30—**The American Society of Mechanical Engineers,** Statler Hotel, New York City.

Dec. 9-12—**American Institute of Chemical Engineers,** annual meeting, Statler Hotel, Boston, Massachusetts.



Choose your power . . . from 18 work-proved INTERNATIONAL® UNITS

Select the International power unit size that correctly fits your needs—be it for pumping or shallow-well drilling. Pick the fuel with the local economy advantage! You'll get a heavy-duty unit with the inbuilt *maintenance-freedom* of positive temperature control, that features full-length water jackets. You'll get *special-delivery* pressure lubrication through drilled passages. You'll get *wear-defiant, stress-resistant, induction-hardened* crankshaft bearings. You'll get the many other International *stay-put, extra-value* features. You have the choice of 12 carbureted or 6 diesel *work-proved* International Industrial Power Units, 16.5 to 200 net hp.

"My International U-9 gives me more power than I'll ever need for digging these 1,000-ft wells," says C. A. Reid, Wichita Falls, Texas, owner of this 55 hp carbureted power unit. It's powering a cable driller, takes 10 days to sink the average shallow well.

Lowering pressure in sand above 12 wells is only moderate work for this 36.5 hp International U-164 engine, operating 17 x 12-inch vacuum pump 24 hours daily. Output averages a barrel per day per well for Owner E. Winesburg, Sapulpa, Oklahoma.

This 91.5 hp International U-372 has worked 24 hours per day, 340 days per year, drilling 3000 ft. wells in Louisiana. In three years, it has needed no repairs. Owners Lloyd & Langston use butane to profit from local price advantage over other fuels.

Drilling 3800-ft directional, part-whipstocked well in 7 days, 8 hours is the record set with the help of this truck-mounted International-powered air tong compressor. Owned by D. T. Bloom Co, Long Beach, Calif., rig quickly handled all casing.

Your International Industrial Power Distributor or Power Unit Dealer is qualified to recommend and install the engine sized for your system—and to provide parts and service on it promptly and competently. A *good deal* awaits you—see him soon!

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is the new-strength wire in Roebling's

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AS SIZES and constructions go, Royal Blue is like the ropes you have used until now... but the likeness ends there.

Royal Blue is made of Roebling's new 1105 wire, the strongest, toughest wire developed up to now for use in any wire rope.

Royal Blue Wire Rope is as enduring as the wire from which it is made.

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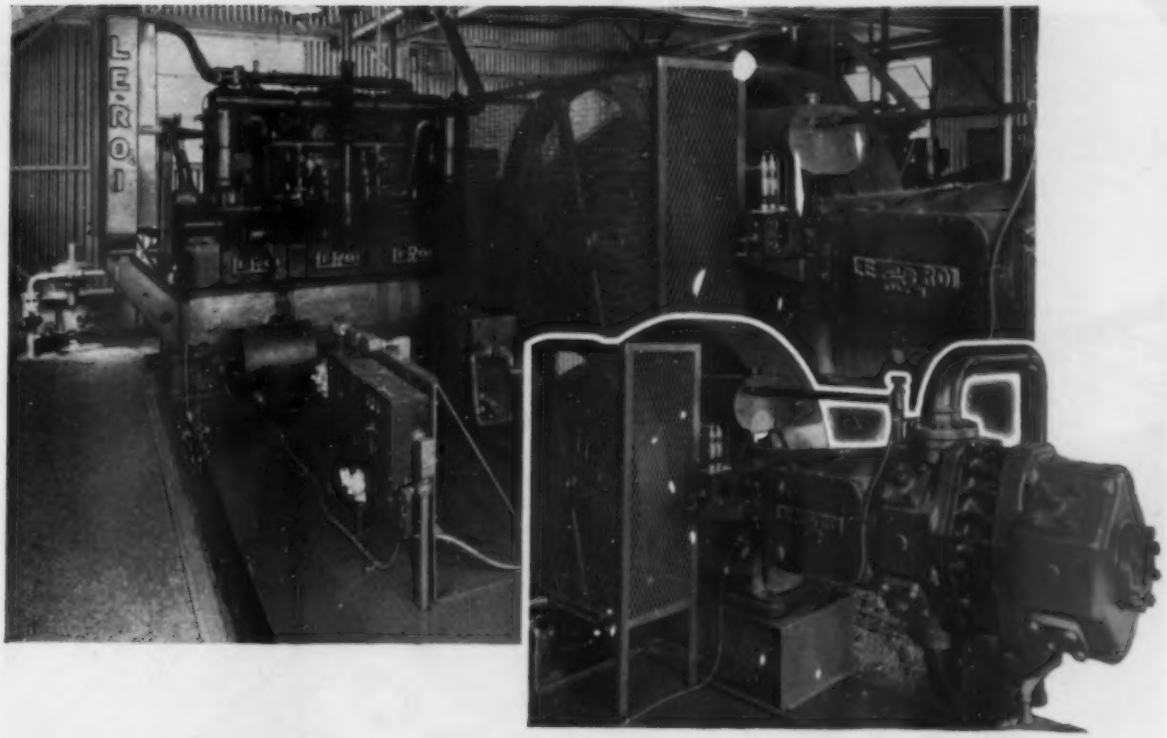


Double Dependability for You

... because Le Roi's semi-portable, package-type, gas-gathering compressors are powered by Le Roi oilfield engines

1. Le Roi gives you a heavy-duty oilfield-type compressor that's built with the same care, the same precision manufacturing techniques used in manufacturing Le Roi oilfield engines.

These compressors are packed with features that make them easy to move around, easy to service. For example, the gas compressor cylinder is sectionalized and can be disassembled without disturbing any pipe connections. Intake and discharge valves are interchangeable and can be assembled or disassembled with only a screw driver, thanks to Le Roi's valve assembly design.

But we're talking dependability — so take a look at these features: Gas compressor cylinder with intake on top, discharge on bottom for self-scavenging of any condensate. Removable cylinder liner in center cylinder section. Oil-tight crankcase with breather. Oil-level gauge for crankcase. Enclosed dust-tight distance piece between cylinder and frame. Metallic wiper rings. Force-feed gas-cylinder lubrication. Metallic-type, full-floating Micarta stuffing-box packing. Micarta piston rings. Closed-end, forged connecting rod to eliminate strap and strap-bolt breakage.

2. You get Le Roi power — power that's proven itself to be outstandingly dependable on drill rig, pipeline gas booster, and generator installations throughout the oilfields. Many of these engines represent the first truly new design concept in 15 years. All of them are compact, high-output units that give you greater horsepower and speed without compromising engine life.

Not only do you get the *only* complete, semi-portable, gas-gathering compressor that is built, backed, guaranteed and serviced by one organization, but you also get double dependability.

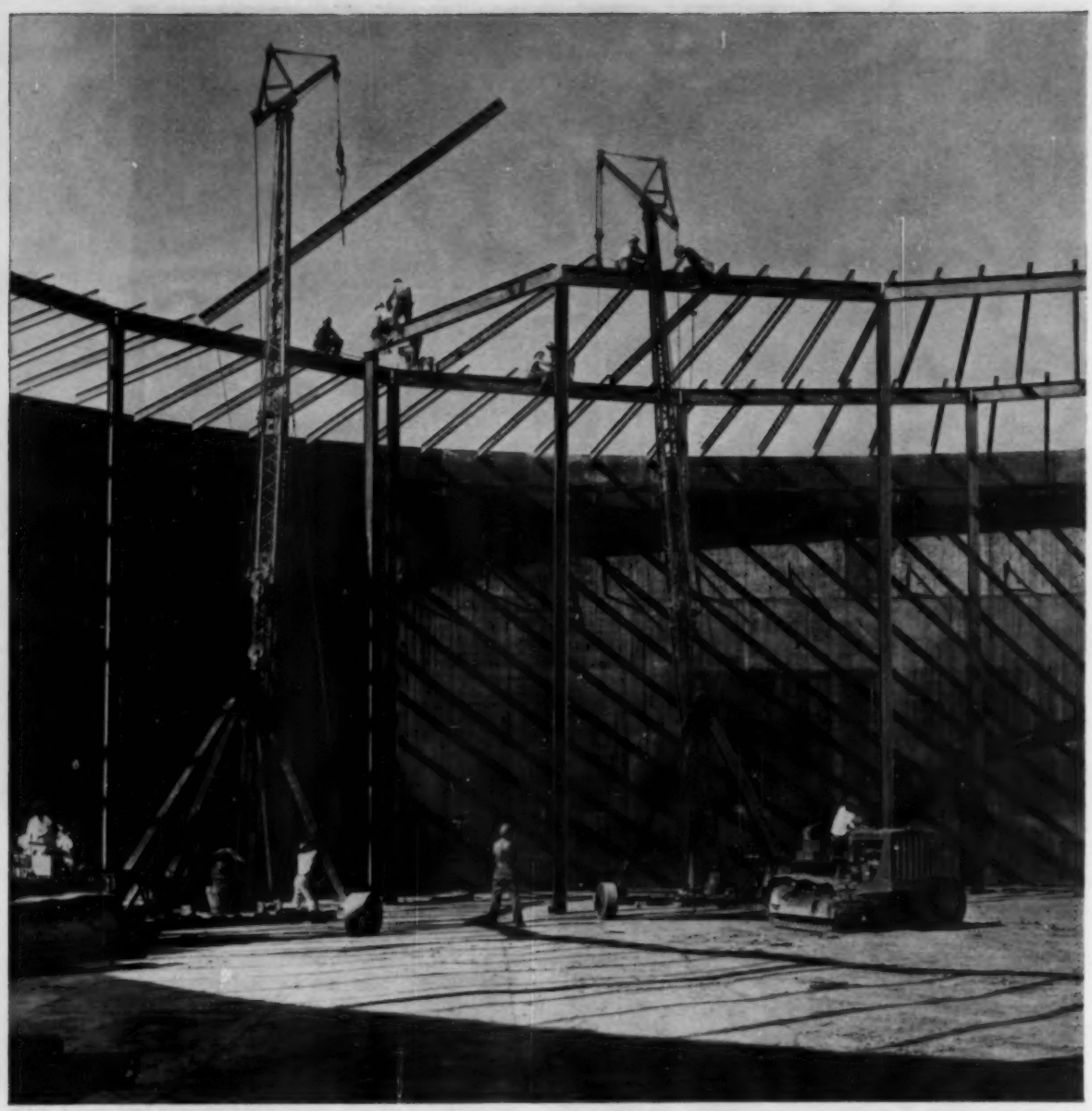
The Le Roi gas-booster line consists of 5-, 7-, 9-, 11-, and 13-inch stroke machines ranging in size to 300 hp. Write Le Roi Oilfield Headquarters, 5000 45th West Avenue, P. O. Box 9487, Tulsa, Okla. for complete information and latest literature.

P-141

LE ROI *Division of Westinghouse Air Brake Co.*

Milwaukee 1 Wisconsin

PORTABLE AIR COMPRESSORS TRACTAIR STATIONARY AIR COMPRESSORS AIR TOOLS ENGINES



We build 'em big

This is a 250,000-bbl tank going up—and it's just one of twelve which we completed recently at a large tidewater terminal. Each of these whoppers measures 200 ft in diameter by nearly 44 ft in height.

Are you considering the expansion of your storage capacity? Whatever size or type of tanks you may have in mind, you'll probably find that we've built a good many of them. Cone-roof, lifter-roof, spheres, and a variety of floaters—pan-type, pontoon and double-deck—they're all available in Bethlehem designs, fabricated and erected to your requirements.

Would you like to have detailed information about Bethlehem Storage Tanks? Just get in touch with the Bethlehem sales office nearest you.

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On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

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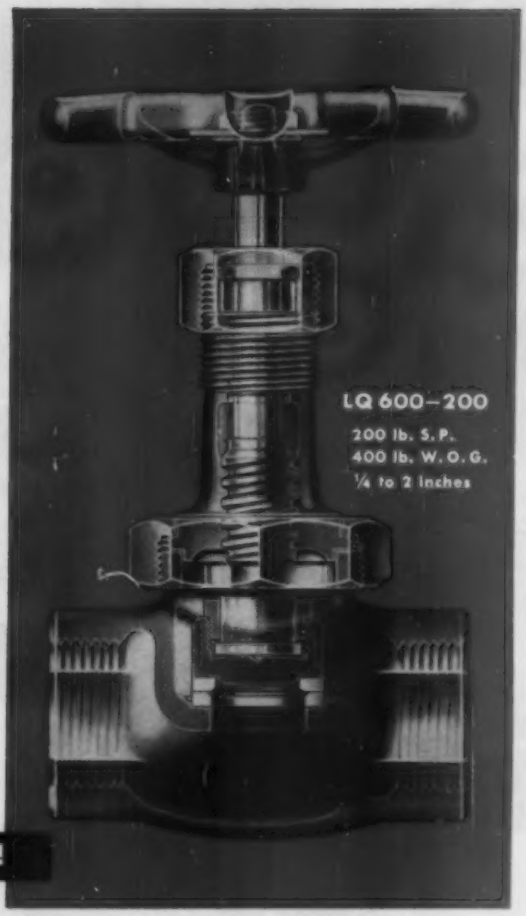
Lunkenheimer Announces

ANOTHER GREAT NEW LQ600 VALVE



200 Lb. S.P.! 400 Lb. W.O.G.!

Lunkenheimer's famous LQ600, the Bronze Globe Valve that set a new high standard of performance on 150 lb. service, is now available for 200 lb. S.P., 400 lb. W.O.G. applications. The new line features the same long-wearing flat seats and discs made of Brinalloy®, plus a body and bonnet of Lunkenheimer's amazingly strong S-1 Bronze for higher-pressure service. Install this great new LQ600 Valve on your 200-lb. pressure lines—including all your toughest services—and compare its performance with other valves. It's built to eliminate maintenance costs because there is no replacement of seats and discs—they are patented Brinalloy, brazed in to stay, harder all the way through and more resistant to wear and corrosion than 500 Brinell Stainless Steel and far exceeding the wear resistance of 1000 Brinell case-hardened Stainless Steel.

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Now there are *TWO* LQ 600 Valve Lines

The original LQ600 Valve for 150 lb. S.P., 300 lb. W.O.G. service has received the fastest acceptance of any valve introduced in years. Thousands of these valves are in service—some as long as five years—without a single reported case of failure or leakage.

FOR COMPLETE INFORMATION WRITE....

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THE ONE *Great* NAME IN VALVES

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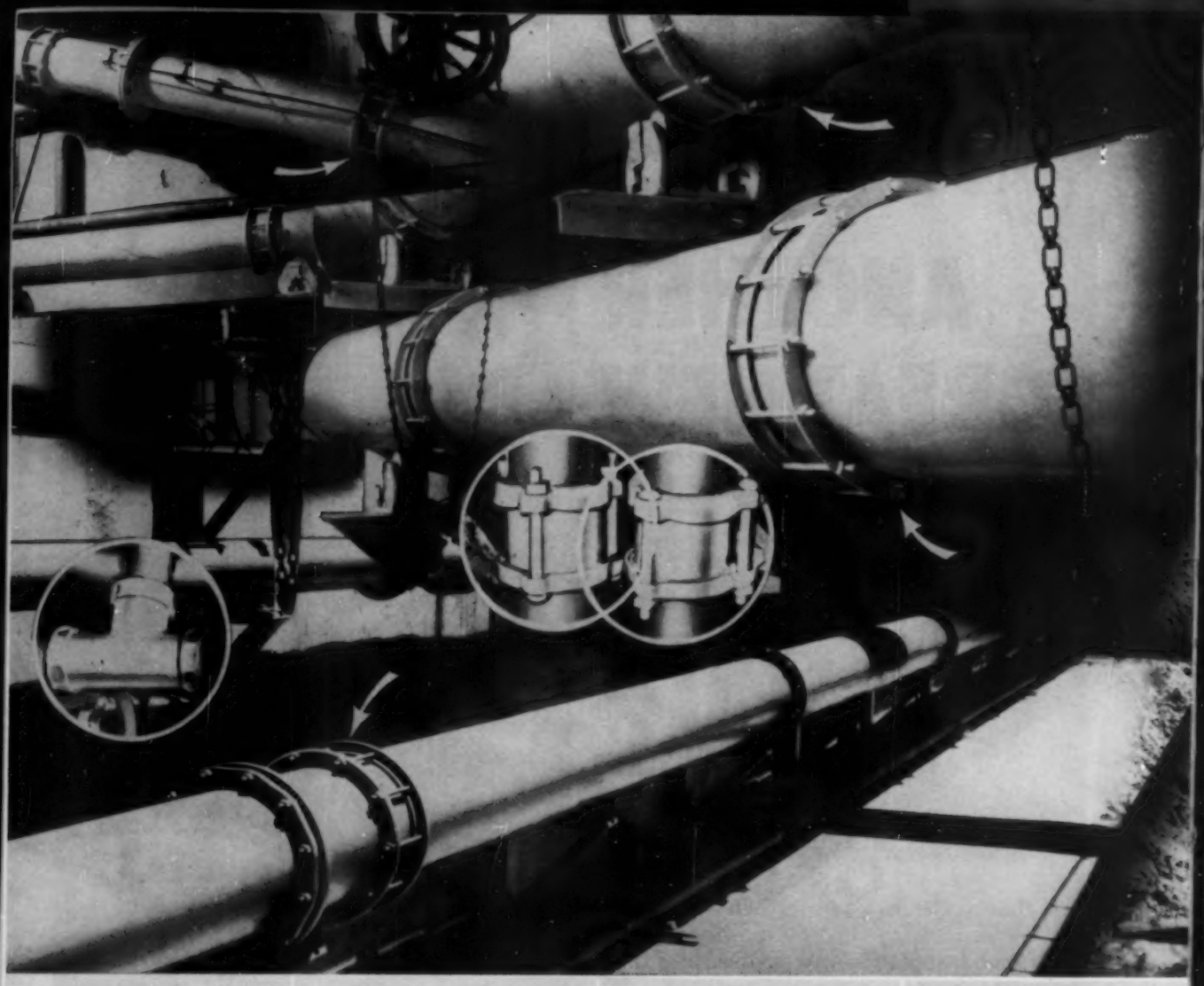

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IDECO, Dallas, Tex.—Hydrair and Power Rigs; Full-View Masts; Substructures; Single, Dual and Drive-In Rambler Rigs; Blocks, Swivels, Rotaries; Mud Pumps; Petroleum Equipment and Supplies.

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MAGNET COVE BARIUM CORP., Houston, Tex.—Magcobar and Magcogel drilling muds and other specialized oil well drilling fluids and chemicals.

Security

SECURITY ENGINEERING DIVISION, Dallas, Tex., Whittier, Calif. — Rock bits, reamer rock bits and hole openers; reamers, casing scrapers and Neo-Red rubber stabilizers.

CLARK

CLARK BROS. CO., Olean, New York—Gas turbines, engines, and reciprocating, centrifugal and axial flow compressors — gas, steam, electric and diesel driven.

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MANUFACTURING DIVISION

plus products for every industry

For more than 75 years Dresser has been the leader in the design and manufacture of flexible pipe couplings and repair devices of the highest quality. Dresser products are used by every gas utility in the country; for scores of applications in water supply and distribution systems, and in every industry — petroleum, refining, chemical, marine, railroad, and many others. Practically *everywhere* pipe of any size is joined or repaired there is a Dresser coupling, repair clamp, or repair sleeve to speed and simplify the job. Continuous research and development, plus Dresser's long-standing reputation for reliable, carefully-engineered and constructed equipment assure you of the right device for every pipe joining and repair problem.

How the DRESSER *plus* + works...

In every industry, Dresser flexible couplings and pipe fittings are teamed with other Dresser equipment – engines, pumps, compressors, blowers, steel products, and oil production equipment – to assure the Dresser *Plus* + in thousands of applications.

Dresser flexible couplings hold fast more than 500,000 miles of pipe for gas pipe line companies and gas and water utilities throughout the world. In the oil industry, they connect gathering, flow, mud, and salt water lines, and are used for such exacting applications as high-pressure transmission lines. The largest coupling ever made – an 18-foot Dresser flexible coupling – joins a penstock for one of the nation's huge hydro-electric power plants.

The extra quality of design and construction in Dresser couplings and fittings is another example of the Dresser *Plus* + in action. This is the extra value you get from the combined experience, research, engineering facilities and resources of *all* the Dresser companies. This outstanding inter-company teamwork provides Dresser Plus + equipment and services . . . the standard of comparison the world over!

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LANE-WELLS CO., Los Angeles, Calif., Houston, Tex., Oklahoma City, Okla.—Electric and Radioactivity Well Logging, Koneshot perforating and bullet perforating, packers and bridging plugs.

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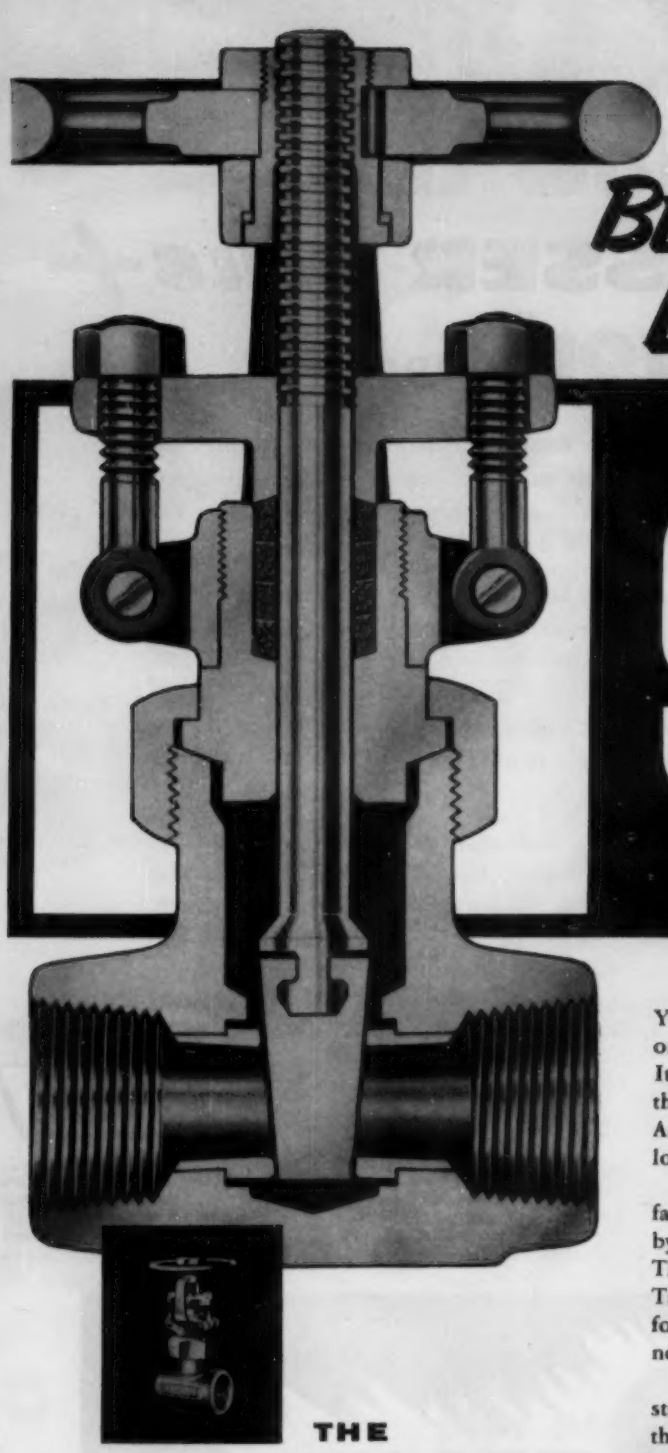

DOES A BETTER JOB AT LOWER COST

CHAPMAN LIST

960

SMALL FORGED STEEL GATE VALVE

You'll find Chapman List 960 specified and used on more jobs than any other valve of its kind. It has the range . . . the construction . . . the tightness . . . and smooth operation you need. And it keeps your maintenance down to a new low even under severe working conditions.

There's no seizing or galling. Wedge gate faces are super tough . . . hardened to 800 Brinell by Chapman's exclusive Malcomizing process. There are no full-pressure repacking difficulties. Taper shouldered stem seats snugly in bonnet forging. Stem-and-gate connections are now 50% stronger than ever before.

With its easily replaceable, hardened stainless steel seat rings, Chapman List 960 is the valve that keeps its mind on the job in multiple applications. Sizes from ¼" to 2" . . . in many different alloys. Rising stem with yoke or rising stem with inside screw. Pressures from 380 psi at 1000° F to 2000 psi at 100° F. If higher, get Chapman List 990.

Full information is in our Catalog 10. Get it. Read it. See for yourself why Chapman List 960 is known more and more every day as the valve man's valve. Write for it now.

THE

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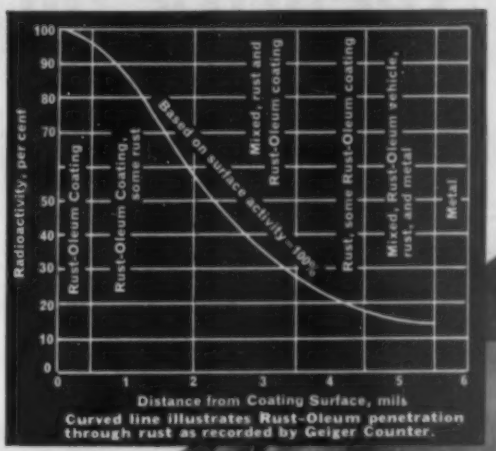
RUST-OLEUM®

PENETRATION

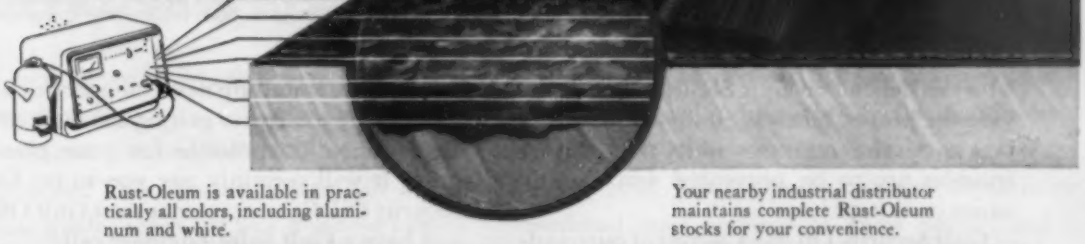
through rust to bare metal traced by Geiger Counter. To effectively stop rust—the vehicle of a protective coating, when applied over a sound, rusted surface—must penetrate through the rust down to bare metal. **Rust-Oleum does exactly that!—as proved by radioactive research!** Rust-Oleum's specially-processed fish oil vehicle was radio-activated and formulated into Rust-Oleum 769 Damp-Proof Red Primer—then applied to rusted test panels. Penetration *through rust* to bare metal by Rust-Oleum's specially-processed fish oil vehicle was then traced by Geiger Counter.

You stop rust, because Rust-Oleum's fish oil vehicle soaks deep down to bare metal and into the tiny pits where it drives out air and moisture that cause rust. You save, because this same *penetration* enables you to apply Rust-Oleum directly over rusted surfaces—usually eliminating costly surface preparations. Attach coupon to your letterhead for your thirty-page report entitled, "The Development of a Method To Determine The Degree of Penetration of a Rust-Oleum Fish-Oil-Based Coating Into Rust On Steel Specimens," prepared by Battelle Memorial Institute technologists.



Curved line illustrates Rust-Oleum penetration through rust as recorded by Geiger Counter.

There is only one Rust-Oleum. It is distinctive as your own fingerprint. Accept no substitute. Buy—and specify only Rust-Oleum. You'll be happy that you did.



Rust-Oleum is available in practically all colors, including aluminum and white.

Your nearby industrial distributor maintains complete Rust-Oleum stocks for your convenience.

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- ☐ Complete literature including color charts.
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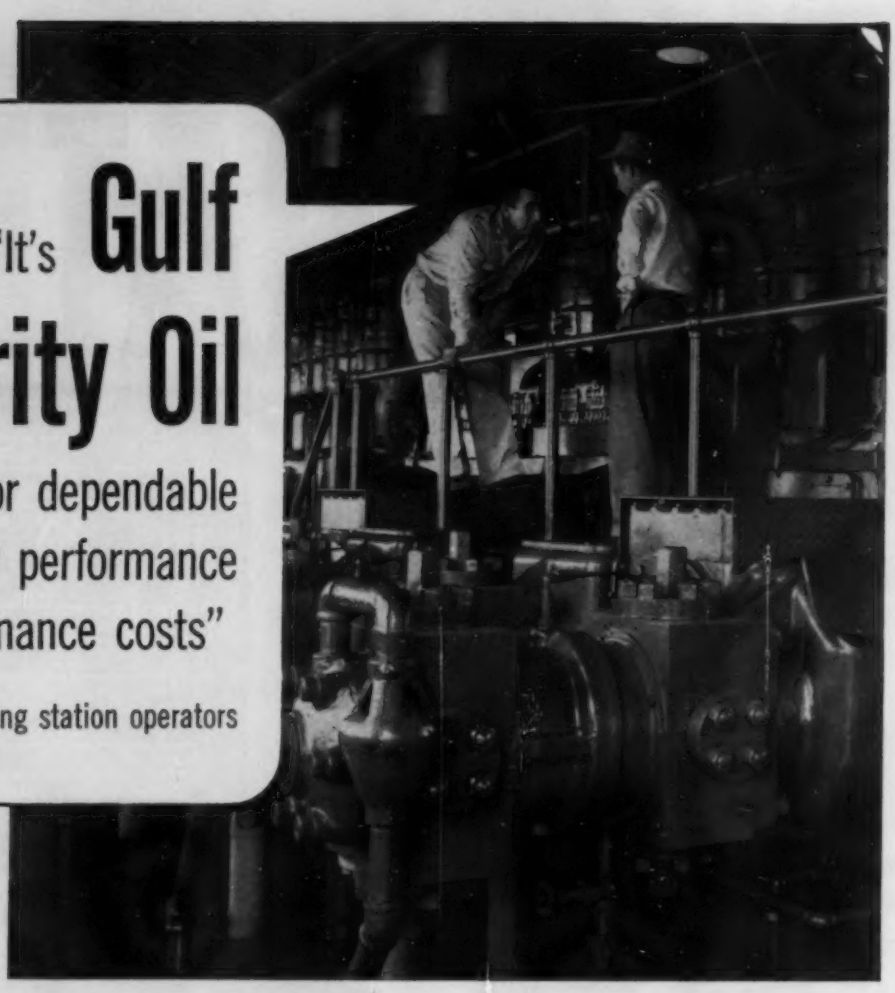
"It's Gulf Security Oil for dependable gas compressor performance and low maintenance costs"

say pumping station operators



Smooth, continuous operation is a must for these units in service at a South Texas gas compressor plant. They are responsible for the steady flow of essential natural gas through pipe lines to homes and industries as far north as Detroit and New York. Gulf Security Oil provides the sure, effective protection needed for cylinders and bearings in both engines and compressors.

You can depend on Gulf Security Oil to provide the proper lubrication that is so important to vital compressor units if operating troubles are to be prevented and maintenance costs kept low.

Gulf Security Oil has a record of outstanding performance in scores of gas transmission plants. After years of operation with this quality oil, the cylinders and piston rings of both the compressors and power assemblies show negligible wear. And few carbon deposits have formed on power cylinder ports and pistons.

If you are installing new compressor units, or feel that you're not getting the most effective lubrication possible for your present units, it will certainly pay you to try Gulf Security Oil. Contact your nearest Gulf Office and have a Gulf Sales Engineer call.

Gulf Oil Corporation • Gulf Refining Company

1822 GULF BUILDING, PITTSBURGH 30, PENNSYLVANIA

GULF

The finest petroleum products for your every need

New! The Sherman Major Power Digger

with Many Advanced Features to Increase Versatility and Earning Power

The all new Sherman Major Power Digger has been engineered to take full advantage of the ruggedness and economy of the Fordson Major Diesel Tractor. This heavy-duty unit will dig 12 feet below grade, reach 18 feet 3 inches behind the tractor rear axle, dig throughout a swing arc of 180° and will carry a full bucket to a height of 8 feet 8 inches for loading trucks.

Additional features of the new Sherman Major Power Digger include twin crowd cylinders, heavy steel plate construction, large diameter hinge pins, heavy steel castings, replaceable hardened steel bearings at hinge points, and a newly designed dipstick, boom, cylinders, bucket and sub-frame assembly.

Write for bulletin No. 1641.

See the Sherman Major Power Digger soon at your local **FORD TRACTOR DEALER**

Sherman
PRODUCTS, INC.
ROYAL OAK, MICHIGAN
POWER DIGGERS* • FRONT END LOADERS • FORK LIFTS

*Designed, Engineered and Manufactured jointly by Sherman Products, Inc., Royal Oak, Michigan. Wein-Roy Corporation, Hubbardston, Mass.

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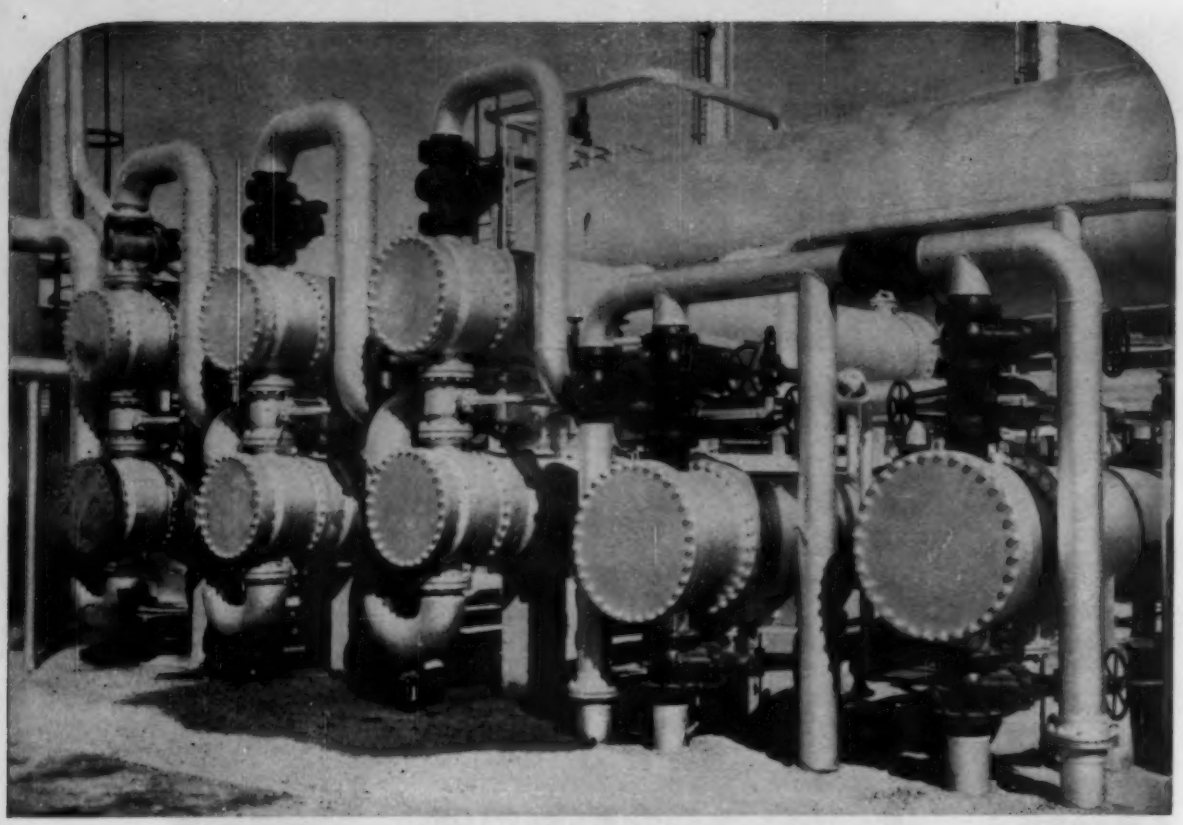
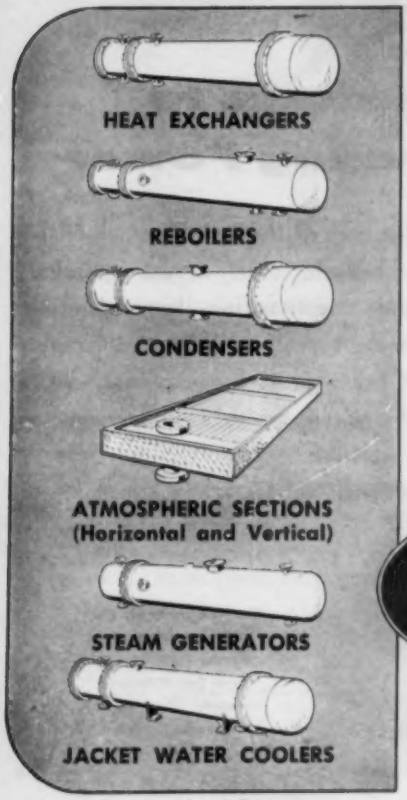


Make sure your Heat Exchangers are



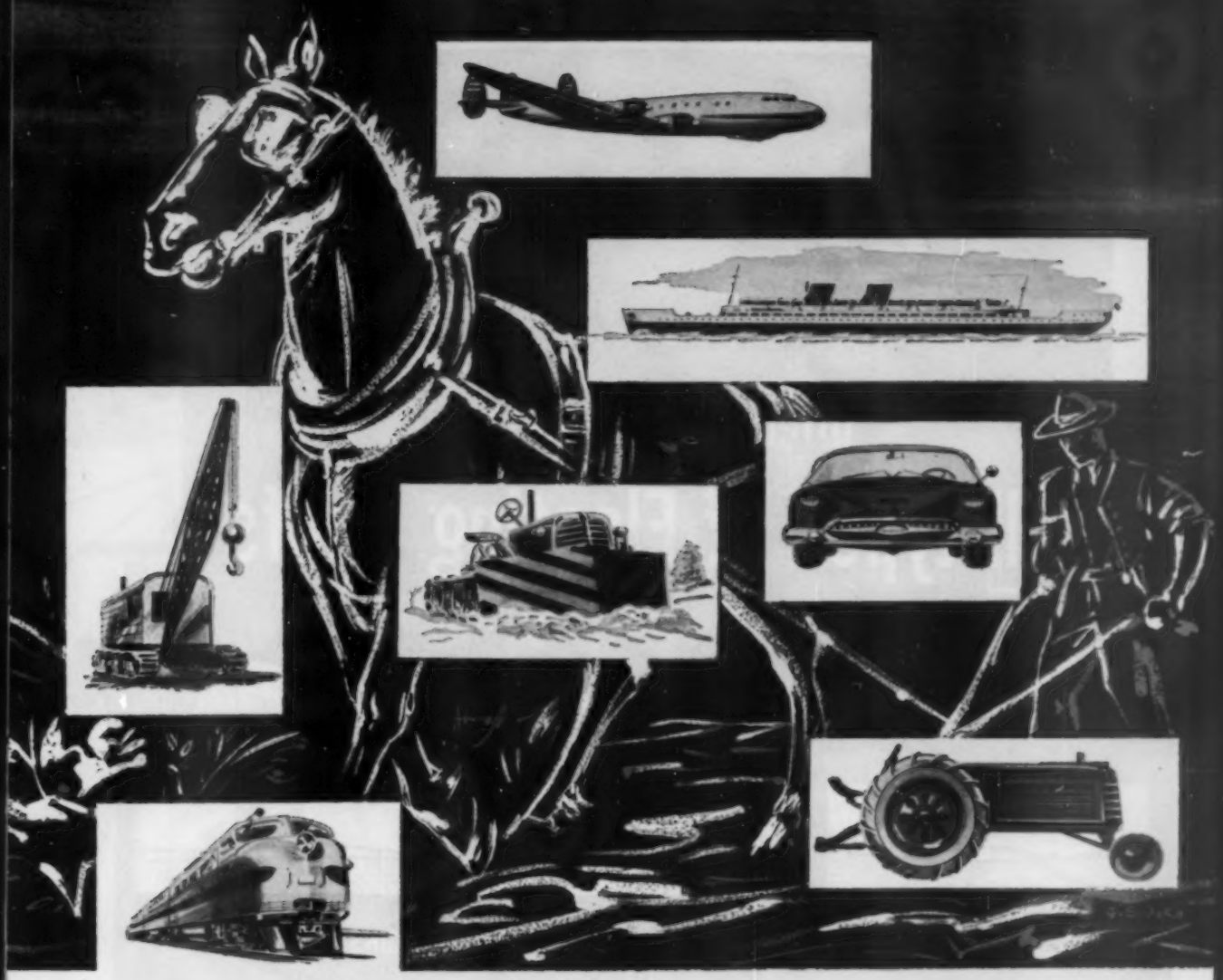
"EFCO Engineered"

● Heat exchangers by EFCO specialists are carefully designed to meet *your* specific requirements. EFCO heat exchangers give you long, trouble-free operation plus the extra advantages of lasting tightness, optimum heat exchange, and minimum maintenance costs.

ENGINEERS & FABRICATORS, INC.
P. O. Box 7395 Houston 8, Texas

EFCO

HEAT TRANSFER EQUIPMENT



The new horsepower needs Paracril!

Steel, rubber, oil, and science have taken the horse out of horsepower—sent Dobbin the way of the kerosene lamp.

The *new* power is oil—oil that burns—oil that drives pistons and turbines in hydraulic systems—oil that lubricates moving parts to give the long reliable life essential to today's power equipment.

And Paracril® is the modern, oil-resistant chemical rubber that's outstanding for its ability to control the power of oil—in gaskets, seals, hydraulic hose and fittings, and a host of other applications where rubber-like properties are required.

Impervious to animal, vegetable, or mineral oils, fats, and greases, Paracril also provides excellent *abrasion resistance*, good *flexibility* over a wide temperature range, great *dimensional stability* and lasting *resilience*.

What's more, Paracril is available in various grades of oil-resistance, in bale or crumb form, and is extremely easy to process. It may be calendered, extruded, molded, or solvated for use in cements and adhesives—blended with plastics or other rubbers to impart special desirable properties.

See how Paracril can be an invaluable plus to *your* rubber products. Learn more about Paracril's many advantages by writing on your letterhead to the address below.

Naugatuck Chemical

Division of United States Rubber Company
Naugatuck, Connecticut

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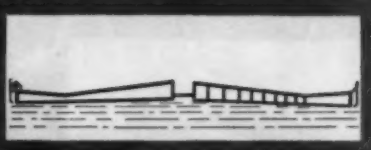

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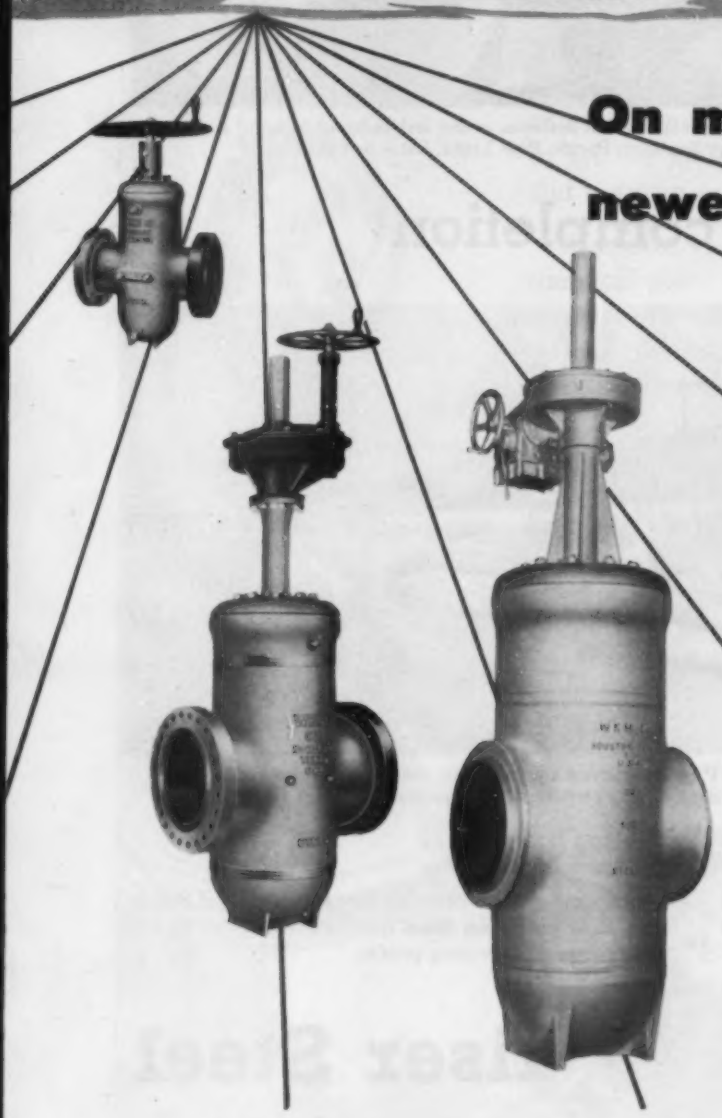

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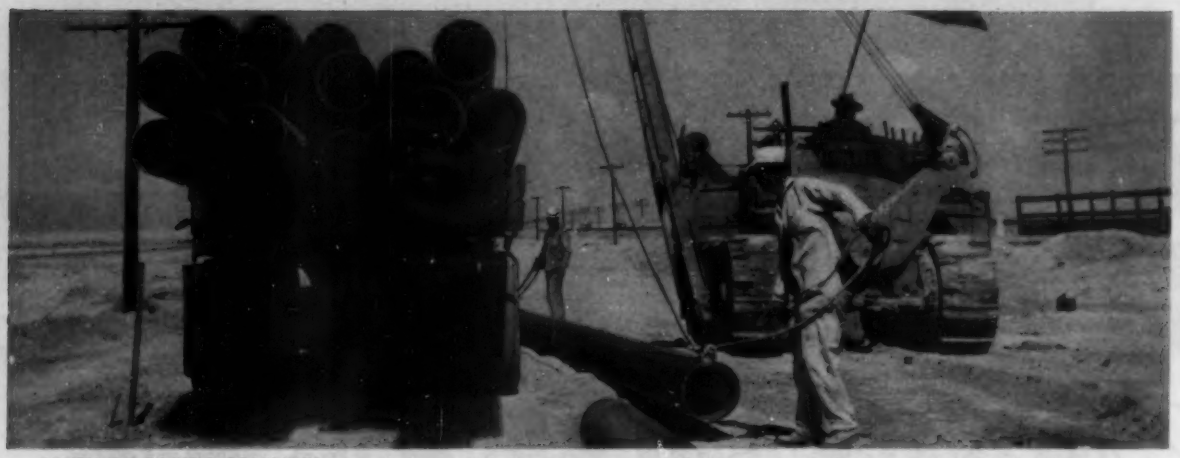
$30,000,000 Southern Pacific Pipeline



SOUTHERN PACIFIC COMPANY, one of the world's largest transportation systems, is the first railroad to build a major pipe line. Construction of this 844-mile line was handled by Southern Pacific Pipe Lines, Inc.—a subsidiary.

rushed to completion

PIPE LINE EXTENDS from Watson, Calif. to El Paso, Texas. Products moved are gasolines, diesel oil and jet fuels. Kaiser Steel line pipe measures up to 52 rigid tests to be sure it meets every requirement on jobs such as this.

SEVEN contractors laying pipe on eight spreads rushed this first Southern Pacific pipe line to completion in 9 months.

Working closely with them was Kaiser Steel, the major supplier of line pipe. Careful planning to make *sure* that top-quality pipe is available when and where it's scheduled is an important part of Kaiser Steel's service to pipeliners.

Next time you are ordering line pipe, think of Kaiser Steel. Rely on Kaiser Steel quality and service to add dollars to your operating profits.

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Top: Name plate from storage tank equipped with Horton Floating Roof.

Bottom: Two 80,000-bbl. tanks equipped with Horton Double-Deck Floating Roofs at Edmonds, Washington, refinery of Union Oil Company of California.

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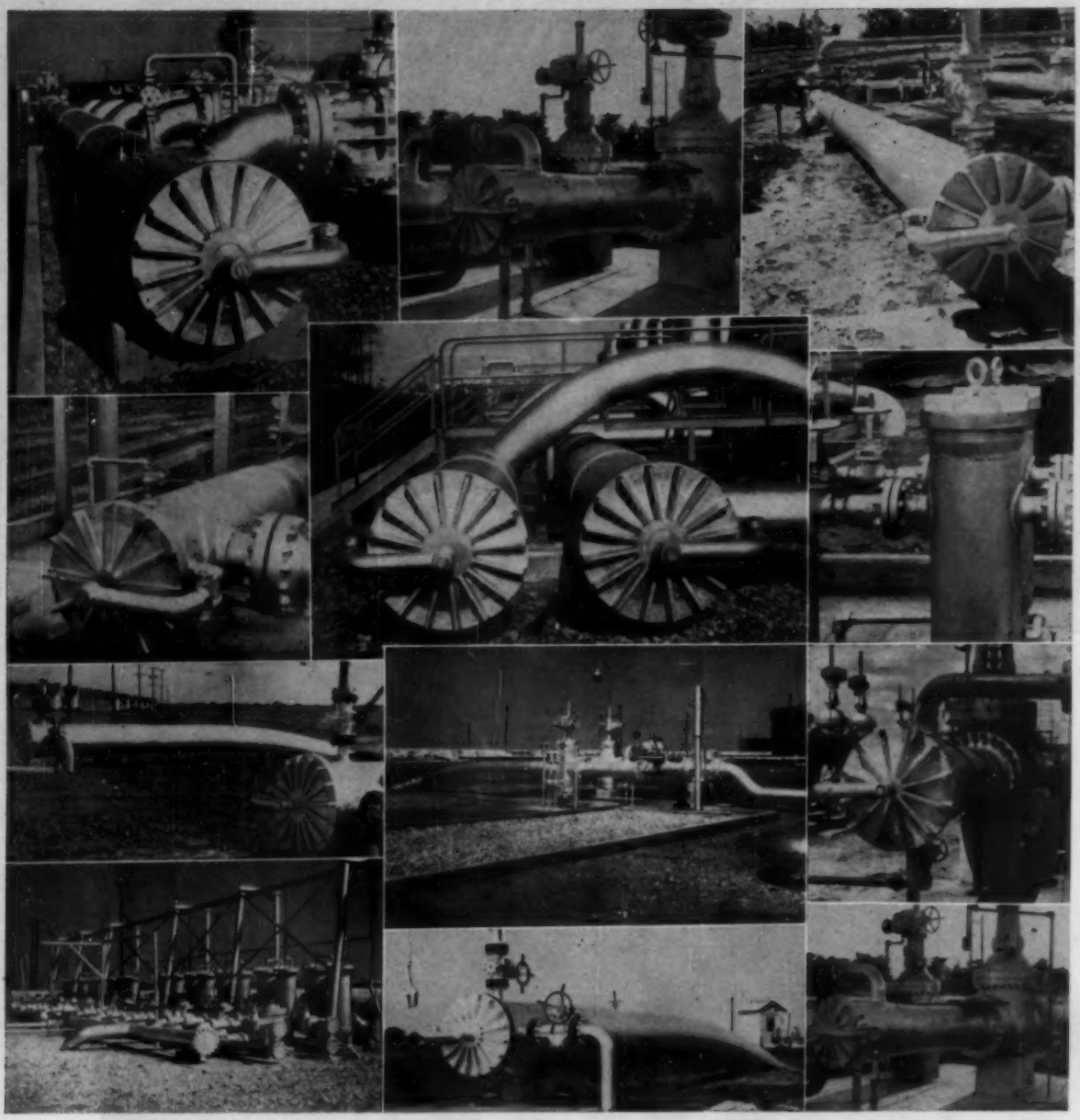

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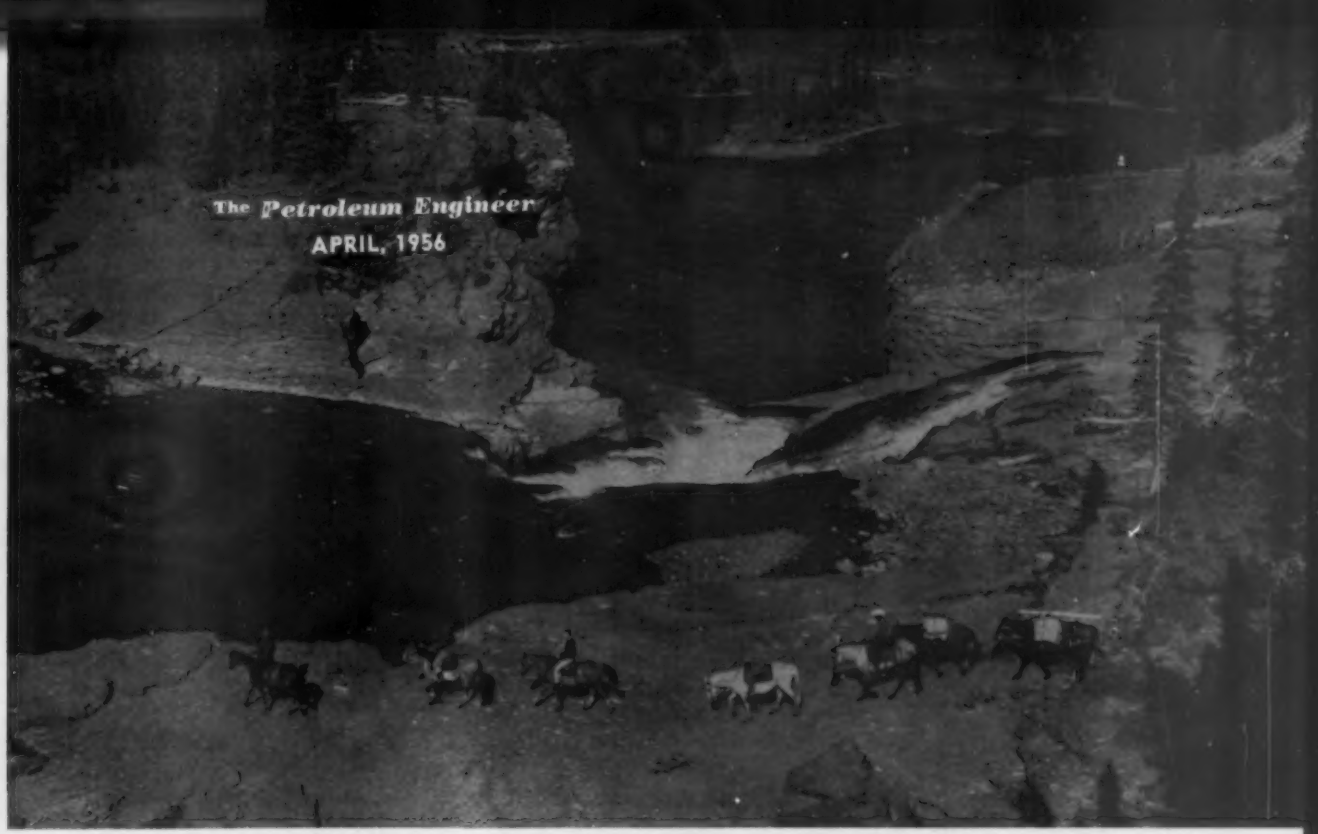

This was a year of intensified exploration and most of it was rugged work. In British Columbia, Western Canada, this exploration crew goes by pack train, the best and sometimes the only means of travel in this terrain.

Socony-Mobil photo

P 100.

WORLD OIL HITS HIGHEST PEAK

The biggest global oil boom in history is reaching the far corners of the earth . . . 1955 saw the largest production and the greatest consumption . . . The world industry was headed for higher records in 1956

Ernestine Adams*

A BOUYANT world petroleum industry soared to new records in 1955. In the 10 years from 1945, production and consumption had doubled. Expansion last year was the largest made in a single year, and 1956 promises to meet at least the increase of 1955.

Predictions for increased demand in the United States are set at about half the 8 per cent rise in 1955, but other nations of the free world are consuming petroleum products on a more sharply rising scale.

Western Europe's economy is based more and more on oil energy. Britain used 20 per cent more fuel oil in 1955 than in 1954. Spain has had an enormous increase with U. S. military activities there. The rise was put at 38 per cent in 1954 over 1953.

For the first time in recent history, oil production in the free world outside the U. S. passed the production in the U. S. Consumption in the U. S. and in the rest of the world were coming closer to a balance. Oil was the biggest single item in world trade. A fourth of the total tonnage of the world's merchant fleet was carrying oil and oil products.

The world was hungry for oil and enterprisers of the industry were making an all-out effort to supply it.

As Arthur W. McKinney, president of The National Supply Company, said in his speech before the AIME in New York: "One of the most important facts about the oil industry . . . is that . . . it is one of the universal resources; the most widely used fuel and lubricant."

He also brought out the fact that international oil business is operated by a growing number of companies in recent years. In 1953, he said, 49 per cent of National Supply's export business went to major oil firms. A year later the figure had dropped to less

*Management Editor

than 30 per cent. Smaller U. S. firms and more foreign concerns were getting into the oil business.

This trend of U. S. petroleum capital and know-how flowing into foreign lands was most marked in 1955. One reason was that high cost of operations in the U. S. had made the high cost of foreign enterprises seem more reasonable. Another was a series of new oil legislation in foreign countries that attracted private capital.

From *The Petroleum Engineer's* estimates of capital expenditures abroad, it appears that $1.5 to $1.75 billion will be invested by U. S. companies in foreign oil operations of all kinds in 1956.

When you consider that the foreign aid bill now before the U. S. Congress calls for $1.9 billion in economic aid (the remainder of the $4.9 billion in military aid) you get some idea of the amazing impact this dynamic industry can and does have on world affairs.

One third of the total U. S. capital invested abroad is invested by the petroleum industry. The high capital requirements for petroleum operations were gaining some recognition. Even state-owned monopolies were receiving larger government funds, although these were still inadequate.

Every year seems to stress one phase of oil operations more than others and 1955 was a year of deals and trades and exploration. In spite of shattered records—or because of them—the far corners of the earth were flown over or painstakingly investigated for potential oil. The industry was preparing for the future demand, which promised to grow as so-called backward countries rushed toward a new and more satisfying standard of living.

And the oil is there for the fortunate ones who find it. Wallace E. Pratt, famous geologist now retired, gave his latest estimate of reserves, proved and possible, and they are startling (see table). As he says, most long range estimates in the past have been far too low. A fact that has been demonstrated year after year.

He places ultimate recoverable free world reserves at 900 billion barrels with 170 billion—or 19 per cent—in the U. S. Ultimate gas reserves he estimated at 3850 trillion cubic feet with 850 trillion in the U. S., which is 22 per cent.

Results of a survey brought the following thumb-nail sketches of petroleum events in the countries and territories of the world for the year of 1955.

World Oil and Gas Potential

Wallace E. Pratt, retired vice president of Jersey Standard and renowned geologist, has made an estimate of world oil reserves for the Joint Congressional Committee on Atomic Energy. His figures contemplate a recovery of only 40 per cent of the oil in place and on this basis he feels that the figures are conservative.

Free world estimates in billions of barrels by areas as of December 31, 1954, are as follows:

	Liquid hydrocarbons Billions of bbl	Natural gas Trillion Cu Ft
United States	35	212
Other N. America	7	20
South America	27	43
West Hemisphere	69	275
Western Europe	1	3
Middle East	230	62
Oceania & Far East	6	4
East Hemisphere	237	96
World	306	344

NINTH ANNUAL ROUND UP OF WORLD OIL ACTIVITIES

ADEN

R. C. 120,000 b/d

This is the first full year of operations for British Petroleum Company's Aden refinery. Average throughput was 85,000 b/d.

BP's subsidiary, D'Arcy Exploration Company, has an oil exploration license covering the British group of Kamaran Islands and their territorial waters. Geological, gravity and magnetic surveys are under way. The islands lie off Yemen, north of Aden, but are administered by Aden.

AFGANISTAN

The laws governing foreign investment are attractive here but no private capital has come from outside to explore the sedimentary basin in the north, which extends into Russia. The government has considered contracting the work with firms of various nationalities, but so far no deal has been made.

ALASKA

Rather large oil and gas leasing blocks are now held in Alaska by eight major oil companies: Phillips Petroleum-Kerr McGee joint venture, Ohio Oil, General Petroleum, Richfield, Shell, Standard of California, Sunray-Mid Continent, and Union of California.

Smaller companies, mostly local, also hold leasing blocks: Iniskin Unit Operators (Havenstrite), Alaska Oil and Gas Development, Fairbanks Oil and Gas, Anchorage Gas and Oil Development, Inc., Far North Oil and Gas, Alaska Gulf Oil and Gas, and Alaska Propane Gas and Oil. All of the companies listed conducted field explorations and/or actual drilling in the search for oil or gas. Nearly 6 million acres are now held under lease by oil companies and individuals and 5 rigs are operating.

Phillips Petroleum completed its second test in the Icy Bay area. No official report has been issued by the company but a third and deeper test has been spudded near the second one. Phillips will also have a test under way in the Katalla area with a second rig in 1956.

Iniskin Unit Operators deepened a test at Chinitna Bay to over 9000 ft before suspending operations for the season. Alaska Oil and Gas Development extended its Nelchina test to 2900 ft and Anchorage Gas and Oil started a gas test at Houston, reaching 2000 ft at the close of the season. Alaska Gulf Oil and Gas drilled a test in the Goose Bay area to a depth of 3900 ft which was plugged and abandoned.

Richfield has announced plans for a deep test on its Kenai Peninsula holdings in 1956. Standard of California has an agreement with the Interior Department covering a large acreage on the Kenai Peninsula, which calls for future drilling. It conducted gravity meter studies and engaged in geological mapping in the Cook Inlet area.

Big pipe line project in Alaska in 1955 was the Haines to Fairbanks 620-mile 8-in. military products pipe line. Termed more easily protected than the sea route, it is a chilling reminder of the strategic importance of this north territory. The $40 million 12,000 b/d capactiy Alcango line has five pumping stations and supplies gasoline, diesel oil, jet fuel and other products to U. S. military installations.

ALBANIA

Prod. 4300 b/d? R. C. 3000 b/d?

The refining capacity estimate is made with the understanding that the 3000 b/d refinery at Cerrick has not gone on stream.

Demand in Albania is estimated at 3200 b/d. When the new refining capacity is used, there will have to be some crude imports, perhaps from Russia and Romania.

ALGERIA

Prod. 1600 b/d

Despite political tumult, oil exploration is heavy in this French territory in North Africa. Production was down, however, and wildcatting was unsuccessful both in North Algeria and in the Sahara. There were 19 geological and 15 geophysical crews and 16 rigs in operation most of 1955. Of the 51 wells drilled 19 were productive.

All the crude oil from the 49 wells at Oued Gueterini field (only producing area) is exported and 17,760 b/d of products are imported for consumption.

Six companies and combinations hold leases in the country. SNREPAL (owned 50-50 by French and Algerian governments) is most active. It discovered Oued Gueterini field. Petroleum laws here are attractive to outside operators.

ANGOLA

Prod. 300 b/d

Oil was discovered in this Portuguese territory by Lobite Purfina, an associate company of the Belgium Petrofina group. The well, Benfica No. 2, is in the Cuanza Basin, 22 miles south of Luanda, where the country's large terminal is situated. Initial production was 300 b/d of light oil from about 8500 ft. Benfica No. 3 is being drilled.

A third well was drilled by the company at Morro da Cruz. During 1955 Petrofina put in 44 geological party months

and 24 seismic party months. One rig is operating.

Permission has been granted Lobito Purfina by the Portuguese government to build a refinery in Angola of 10,000 to 20,000 b/d capacity.

ARGENTINA

Prod. 71,000 b/d **R. C. 195,000 b/d**

When the Peron regime was overthrown, the new head of state, General Leonardi, declared that Argentina would manage its own oil operations. Just before he fell from power, Peron had begun to take the more realistic course of asking foreign operators to come in. An exploration agreement had been signed with Standard of California but the Argentine Congress failed to ratify it. Negotiations were under way with Jersey Standard and Shell.

Petroleum imports are the largest single factor in Argentina's trade imbalance. Russia supplied 11,000 b/d products, mostly fuel oil. Consumption in 1955 averaged about 190,000 b/d although imports were cut to a minimum. Domestic refining runs were 160,000 b/d.

Besides products, Peron had made a deal with the Soviet for oil equipment. When the machinery finally came, it was considered obsolete by U.S. standards.

There is some hope of increasing production by constructing more pipe line outlets but there is no strong assurance that reserves would make the lines economical. Campo Duran field in the north could produce more and a pipe line is proposed from Salta to San Lorenzo, on the Plate River.

YPF, the Argentine state monopoly, handles most operations. Fifty-five rigs were operating in 1955 and 7 geological and 15 geophysical crews were in the country. Only news of successful drilling was a report that YPF had found new production in the Tierra del Fuego area next to the Chilean fields in the extreme south.

Argentine produces about 30 billion cu ft of gas a year.

AUSTRALIA

R. C. 196,900 b/d

West Australian Petroleum (80% Caltex — 20% Ampol) evidently has a 2-well field at Rough Range in far west Australia. Oil was found in 1953 and one offset drilled close had production but eight wells have been dry. The company is still searching at the cost of some $8 million annually. One well drilled at Cape Range, 25 miles from Rough Range, went below 15,000 ft. Frome-Broken Hill (BP, Stanvac, et al), is also exploring.

Eight rotary rigs are operating and there are 24 geological and geophysical crews working.

With its 160,000 b/d oil demand for oil products, Australia applauds exploration wholeheartedly.

Refining capacity is building up rapidly. Completed were: Australian Oil Refining Ltd. (Caltex) refinery of 22,000 b/d capacity at Kurnell; Vacuum Oil (Stanvac) 25,000 b/d plant at Altona; Australasian Petroleum Refining Ltd. 60,000 b/d refinery at Kwinana. Total refinery runs average about 107,000 b/d so far.

AUSTRIA

Prod. 73,322 b/d **R. C. 53,000 b/d**

For the year 1955 again, it is still impossible to give a clear review of the position on the oil sector since it was only in August of 1955 that the bulk of Austria's producing oil fields and refineries was transferred by the USSR to the Austrian administration. In consequence, an account of the movements on the oil sector in the first 8 months of 1955 is not available. Nineteen rigs are now in operation.

In 1955, a total of 3,666,112 tons of oil and 766 million cubic meters of natural gas was produced. Reserves are close to a half billion barrels.

To bring pressure to bear on the Soviet Mineral Oil Administration, restrictions on fuels were liberalized early in 1955. This measure resulted both in an essential increase in imports and in price cuts. Imports increased to 384,193 tons. As against the year before, the consumption of gasoline in 1955 rose by 33.3 per cent to 251,000 tons, the consumption of diesel oil was 22.3 per cent higher than in 1954, amounting to 274,370 tons. Compared with 1954, the consumption of fuel oil increased by 26.4 per cent to 945,802 tons.

The year of 1956 will be the first to give a correct picture of Austria's oil industry for some time.

The effect of Austria's oil industry bled by the conquering USSR (with whom Austria was not war) will be felt at least 10 more years. In order to have its resources returned, Austria promised the Soviet 20,000 b/d of crude oil for 10 years.

BAHAMAS

Bahamas Exploration Company, Ltd. (Gulf) retained its license during 1955 and planned seismic operations in the Cay Sal Bank area for 1956. Nasasu Oil Mining Company, Ltd., also holds a prospecting license. Bahama California Oil Company (Standard of California) conducted marine seismograph exploration activities in the area in which it holds 5 licenses totalling about 9.7 million acres.

BAHRAIN

Prod. 30,000 b/d **R. C. 186,500 b/d**

Bahrain's claim to fame this year is an election in March. The Sheik has spent oil money mostly in education and health projects—now allows vote for officials who will run these services for the island's 120,000 people. This is unheard of in the Middle East.

Bahrain Petroleum (Caltex) is running about 210,000 b/d through its refinery. Construction going on to be completed in 1957 includes a vacuum unit of 23,000 b/d capacity; an FCC unit with 18,000 b/d; poly plant with 1500 b/d product; and a diesel desulphurization unit of 11,000 b/d capacity.

Production has changed little at Awali field. Gas provides pressure maintenance for the field and is sold on the island. In 1955, three rigs drilled 14 development wells to keep up the field, which has nearly 100 producing wells. Oil reserves are about 200 million barrels.

BARADOS, B. W. I.

Barbados Gulf Oil Company, Ltd., holds a prospecting license over about half of the Island of Barbados (north of Trinidad), which also extends into portions of the territorial waters adjoining. The company's first wildcat test, Gulf Turner Hall No. 1, was drilled to 11,352 ft, but did not find commercial oil production. It was, however, completed as a gas well and sold to The Natural Gas Corporation.

Gulf Ince No. 1, was temporarily abandoned November 19, 1954, at 5078 ft after testing some shallow gas. Gulf Adams Castle No. 1, southwest of Bridgetown, was drilled to 5269 ft and abandoned.

Gulf Spring Vale No. 1 commenced in 1955 was drilled to 12,178 ft, and testing started a few days before the end of the year. Gulf's fifth well, Gulf Friendship No. 1 was spudded.

British Union Oil Company, Ltd., has a prospecting license for the balance of the island, including some territorial waters and is carrying out a geological reconniassance.

Some 7600 b/d products and 60 b/d crude oil is imported.

BELGIAN CONGO

Petrofina, Belgian firm, has spudded in on a second location at Dekeze on Lukenie, province of Kasai. The first wildcat between Stanleyville and Coquilhatville was dry. There is one rig in the territory.

The African territory imports some 10,000 to 12,000 b/d oil products.

BELGIUM

R. C. 123,100 b/d

The only exploration license in the country is owned by Petrofina and covers a small area near the Netherlands border.

A polymerization unit and catalytic cracking plant installed in 1955 at the BP and Petrofina refinery at Antwerp increased capacity from 36,000 to 65,000 b/d. At Esso Standard's Antwerp refinery, capacity was expanded from 25,000 to 35,000 b/d.

"Albatros" S. A. Belge Pour le Raffinage de Petrole refinery at Antwerp is being increased from 12,000 to 15,000 b/d

Gulf Oil is reported interested in constructing a 20,000 b/d refinery at Antwerp.

BOLIVIA

Prod. 7376 b/d **R. C. 12,300 b/d**

Oil production is assuming important proportions in Bolivia's economy, making up to some extent for lost tin markets. At the end of the year production was about 7900 b/d. With consumption only 4200 b/d, almost half the output is shipped to neighboring countries.

An 8 and 10-in., 213-mile pipe line is being constructed by Williams Brothers, Tulsa contractors, from Aroma to Arica, Chile, which will give Bolivia another outlet for crude oil. A pipe line is proposed from Sicasica, near La Paz, to the Port of Arica, Chile. The 6000 b/d capacity line would cost about $10½ million.

All four refineries belong to Yacimientos Petroliferas Fiscales Bolivianos, the government company. Those at Cochabamba and Sucre have been modernized.

YPFB had all oil concessions until Glenn McCarthy's company was granted a concession in 1953. Part of the interest was sold last year to Commercial Corporation of New York and Sure Oil Company of Denver, Colorado, to get funds to develop the 970,000-acre concessions after one oil well and one gas well were brought in. The $4 million program calls for drilling 35 to 45 more wells.

One is drilling at present on this concession plus 7 rigs running for YPFB. Four geological parties and 2 geophysical crews are working.

Recently a new Bolivian oil law went into effect. Exclusive exploration concessions may be granted for periods up to 10 years, and exploitation concessions up to 40 years. They may in each case cover up to 7.4 million acres. Royalty will be 11 per cent, and income tax will not exceed 30 per cent. Depletion allowance will be 27 per cent of the gross value of oil or gas, and capital may be written off at an annual rate of 20 per cent.

BORNEO (British)

Prod. 109,000 b/d **R. C. 47,300 b/d**

Brunei. Seria field averaged more than 100,000 b/d for the first half of 1955 from some 560 producing wells. A gas processing plant was installed in 1955 which extracts about 1750 b/d liquid products. The field produces about 115,000 MCF/d of gas. A new 40-mile crude oil line carries the output from Seria to the Lutong refinery in North Sarawak.

An encouarging show of oil at 3500-600 ft was found at Jerudong, 45 miles northeast of Seria. It was the same gravity, 38 API, as Seria oil, which is produced from 4000 to 7000 ft. Seven rigs were operating.

Sarawak. Throughput at Lutong refinery runs about 48,700 b/d. Miri field was producing almost 1300 b/d. Other crude is shipped to Geelong in Australia for processing.

North Borneo. Exploration continues in this territory.

British Malayan Petroleum (Royal Dutch-Shell) has all operations in British Borneo.

BORNEO (Indonesia)

Prod. 17,000 b/d **R. C. 56,000 b/d**

This is the main part of the island, formerly Dutch Borneo. Operations are carried on by Royal Dutch Shell.

(See Indonesia)

BRAZIL

Prod. 5400 b/d **R. C. 106,000 b/d**

With an inland consumption of some 175,000 b/d oil products, Brazil's imports are a drain on its economy. Increase of consumption last year was up only 10%, lower than former increases.

Operations remain in the hands of Petrobas, the state monopoly. It gets $50 million a year from the government which is inadequate to develop reserves and enlarge refineries at Bahia, which is being expanded from 4000 to 14,000 b/d; at Mataripe, from 5000 to 15,000 b/d (now on stream); and at Cubatao, from 45,000 to 70,000 b/d. Further additions are to be made at Cubatao and Mataripe and a new topping plant is being built at A. Bernardes.

Nine drilling rigs are running and more have been ordered, especially for the new area in Nova Olinda on the right bank of the Madeira River in the Amazon Valley. Until this discovery of oil at 9000 ft, Bahia in the east had the only production. Output is about double last years.

Laws are unfavorable to private capital and especially to outside oil capital. "Petroleum is ours," is one apparently respected slogan of Brazil's large communist party.

BRITISH GUIANA

East of Venezuela at the top of South America, this country has granted its first offshore oil concession. The license goes to McBride Oil & Gas Corporation, San Antonio, Texas and covers a 4000 sq. mile area offshore.

BULGARIA

Prod. 500 b/d? **R. C. 52,250 b/d?**

The new refinery built at Varna with a 50,000 b/d capacity is reported on stream. Other refineries are three at Russe.

The first oil production was found in the Rogatshevo area, northwest Bulgaria, at about 5500 ft in 1951, according to a Soviet news agency but it was not until the end of 1954 or early 1955 that oil was produced commercially. Exports to West Germany were about 200 b/d in 1955.

All operations are under state control in this Communist state.

BURMA

Prod. 4430 b/d **R. C. 2900 b/d**

Political unrest has restricted exploration here. Only one geological party is working and two drilling rigs. The first wildcat since before WW II has been planned in Magive district.

Total oil production in Burma during 1955 amounted to about 1,617,500 bbl. This is comparable with the estimated daily average of 4250 bbl for 1954. Cumulative production to the end of 1955 was about 295,381,000 bbl.

Burmah Oil Company, sole operator in the country, is constructing a 400 b/d distillation plant near Rangoon, expected to go on stream July, 1956. This is the site of the old Syrian refinery destroyed by the Japanese. The present Chauk refinery has a 2900 b/d throughput.

CAMEROUN

The one drilling rig operating in Cameroun put down 3 wildcats in 1955 and two had significant shows. At Logbada, gas was found, and at Sonellaba, oil was in evidence. Exploration is carried on by a French government firm in the West African territory.

CANADA

Prod. 362,400 b/d **R. C. 620,000 b/d**

Western Canada's 1955 crude oil production of 129,000,444 bbl was an increase of approximately 33% over the previous year's production. However, this represented only about 60% of Canada's potential production. Exports of Canadian crude oil to the Puget Sound and Lakehead-Minneapolis regions of the United States increased substantially during the year. The daily average exported to these regions was 54,000 bbl but by the end of the year exports had reached 100,000 bbl a day. A significant event at the end of the year was the first shipment of Canadian crude oil going to California.

During the year some 250 rigs drilled 2935 wells for a total footage of 12, 713,000. This is an increase of approximately 30% over 1954 and led to significant discoveries such as the first commercial oil well in British Columbia, major Mississippian discoveries in Sundre, Westward Ho and Harmattan areas in Alberta and the Battrum field in southwestern Saskatchewan. Developments in the year saw important extensions to the Pembina field in Alberta. This field approximately doubled in area as a result of 650 well completions. Also, important extensions were recorded in Southeast Saskatchewan and Southwest Manitoba.

The most significant factor regarding pipe lines in Canada was the green light given to Westcoast Transmission Company's gas pipe line from the Peace River country to link with that of the Pacific Northwest Pipeline Corporation to supply British Columbia centers and the north western United States. Westcoast's phase of the system began preliminary construction in 1955 and is scheduled for completion in late 1957. Also of major interest was the progress of Trans-Canada Pipe Line's proposed gas line from the Alberta-Saskatchewan border to eastern Canada. Factors having a bearing on the construction of this line are: (a) the Federal Power Commission's decision on Tennessee Gas Transmission's proposal to import Canadian gas into the mid-western states, and (b) the Canadian government's decision to form a crown corporation for the financing of the line through the sparsely populated Ontario.

Other progress of significance regarding distribution systems was the commencement of the Peace River pipe line, which will carry crude from the Sturgeon Lake region to the Trans Mountain Pipe Line and the completion of the South Saskatchewan pipe line which led to the export of Southwestern Saskatchewan crude to the Lakehead-Minneapolis region. Also, the Westspur pipe line was commenced during the year which will carry Southeastern Saskatchewan crude oil to the Interprovincial pipe line.

Refinery capacity in Canada increased by some 60,000 bbl per day to a total capacity of approximately 620,000 bbl a day. A major factor contributing to this increase was the completion of the Canadian Petrofina 20,000 b/d capacity refinery located in Montreal, Quebec. Also of major importance was a 7000 b/d increase in capacity of the North Star refinery at St. Boniface, Manitoba.

Imperial Oil is adding a 15,000 b/d catalytic reformer, a wax recrystallization and lube hydrofiner at its Sarnia plant; also a 15,000 b/d cat reformer at its Montreal plant.

CEYLON

A $30-million refinery has been proposed by the Government of Ceylon to be constructed near the Capital, Colombo, and to use Middle East crude oil. This would supply the 16,000 b/d products demand in this island off the tip of India.

Canada has been requested to give assistance in carrying out an aerial geological survey to search for oil.

CHILE

Prod. 8000 b/d **R. C. 20,700 b/d**

Chile's consumption of 35,000 b/d has given them an oil import headache. Despite increase in production in the Chilean fields in the Tierra del Fuega and Punta Delgada areas, output is limited. Five rigs are drilling on the Main Island of Tierra del Fuego; 3 geological, 3 seismic and a gravity meter crew are operating. Most of the 38 million cu ft of gas is treated in a small absorption plant and injected for pressure maintenance.

All exploration and development is done by the state company, Empresa Naticional del Petroleo.

The new 20,000 b/d plant at Concon is ENAP's only refinery. Three other very small plants are owned by Chilean private interests.

Pipe line facilities have been extended to Cullen oil field and will be laid soon to the new Flamenco and Calafate fields.

CHINA (Communist)

Prod. 8300 b/d? **R. C. 15,000 b/d?**

Estimating from figures on the 5-year plan ending in 1957, current output is 13,350 with 18,000 b/d the 1957 objective. (This may include shale oil).

Reports say new crude oil producing areas have been found in Tsinghai province, and gas has been discovered in Szechwan. Most oil comes from Kansu's Yumen field.

Pravada (USSR newspaper) estimated 6500 b/d oil production in China in 1954. Bureau of Mines calculations are used here for production in 1955.

An official release stated that 8 oil refineries were completed in 1954.

China Communist Government now owns all oil operations. Russian equipment is used. Imports come from Sakhalin, USSR, and Romania principally.

COLOMBIA

Prod. 112,000 b/d **R. C. 44,650 b/d**

A more liberal oil decree signed in August added more incentive to outside capital. Applications for new concessions

have been made by International (Jersey Standard) Royal Dutch-Shell and Canadian Eagle, Texas, Socony and Richmond (Standard of California). Richmond has an interest in 3.5 million acres in the west and north coast regions. It continued field surveys in 1955.

During 1955 Colombia-Cities Service Petroleum, subsidiary of Cities Service, entered into a contract with Ecopetrol (Empresa Colombian de Petroleos) under which an area known as El Carare, plus some adjoining lands, will be developed under a partnership agreement with Colombia-Cities Service having a 75 per cent interest and Ecopetrol 25 per cent.

Production has increased slowly. Shell's Casabe field is the largest with the Empresa Colombian de Petroleos' De Mares concession second. Empresa, the state-owned firm, is negotiating with Forest Oil Corporation on a water-flooding project at De Mares.

With 21 rigs in the country drilling is fairly steady. Production of natural gas runs about 165,000 MCF/d.

A 12-in. 112-mile pipe line has been built by Texas Company from its Velasquez field to the Andian pipe line at Galan. The latter runs to the Caribbean coast. This permitted production at Velasquez to quadruple to some 17,500 b/d.

Consumption here is about 39,000 b/d, mostly refined domestically. Intercol is building a 28,000 b/d capacity plant at Cartagena with topping, poly and cat cracking units. Colombian Petroleum Company is constructing a 2200 b/d refinery at Catatumbo. Largest present refinery is the 36,500 b/d Empresa plant at Barranca Bermeja operated by Intercol.

COSTA RICA

Union of California had oil showings in its test in the Republic of Costa Rica. The well has encountered substantial thickness of oil saturated limestone at approximately 5400 ft which yielded gas and high gravity oil on several formation tests. Casing will be run to protect the zone and the well will prospect ahead. This is Union Oil's fourth test on its 3,000,000-acre exploratory concession in eastern Costa Rica, the first three being inconclusive. Two geological crews and one drilling rig are operating in this Central American country.

CUBA

Prod. 1500 b/d **R. C. 10,100 b/d**

Oil exploration in sunny Cuba has ridden another boom year. Large and small companies went in singly and in groups—some 50 firms were involved in some way with oil operations.

Trading was the order of the year. Siboney Development and Exploration Company (Crescent Corporation and Sterling Oil of Oklahoma) acquired the stock of 8 Cuban companies from Caribbean Petroleum Associates, Inc., with concession rights to over 5 million acres.

A group of Texans formed Cuban-American Oil Company with options on 1½ million acres.

Kerr-McGee Oil Industries owns a quarter interest in the concession where Echevarria No. 1 in 1954 brought in the first production from a sedimentary formation. Now 13 producers on the Dos Estrellas concession are producing 600 to 700 b/d. Corporacion General de Petroleo de Cuba owns producing area lease. Cuban-Canadian is also active on the concession.

Stanolind has come to an agreement with the Trans-Cuba Oil and the Cuban Venezuelan Oil Voting Trust to carry out an exploration and drilling program over about 12 million acres in Cuba. Under the agreement, Stanolind will acquire a half interest in the concession area when its total expenditure reaches $10 million.

Atlantic Refining conducted exploration studies over an increased concession. Cuban Gulf Oil Company continued geological field and laboratory work, completed a structure drill project and carried out a limited amount of reflection and refraction seismograph work during 1955. Ted Jones Drilling Company discovered oil at 3500 ft, 10 miles east of Havana. Cuba California (Standard of California) made geological studies and did some marine seismic work. It has option rights on 340,000 acres.

Besides the 24 rotary rigs, many cable rigs are drilling in the Jatibonico, Jarahueca, Bucaranao and Motembo areas.

Success has been meager in proportion to effort but the Government welcomes capital with open arms and gives reasonable concessions so a find here would have more value than in a country with restrictive laws.

Procon, Inc., has begun construction of a 20,000 b/d refinery at Santiago de Cuba for The Texas Company. It is expected that the refinery, the first to be built in eastern Cuba, will go on stream early in 1957. It will cost $14,000,000.

A refinery, with a capacity of 25,000 b/d is to be built jointly by Royal Dutch-Shell and Canadian Eagle on Havana Bay, about 5 miles from Havana.

CZECHOSLOVAKIA

Prod. 3500 b/d? **R. C. 34,000 b/d?**

Information is vague from this Communist country. There are estimated to be 6 or 7 refineries and with the new 20,000 b/d Bratislava plant on stream total capacity for all plants is about 34,000 b/d.

Most production comes from the Zistersdorf area near the Austrian border, although the State is carrying on exploration in other areas.

DENMARK

R. C. 750 b/d

Danish American Prospecting Company (Gulf) holds the concession here but there is no geological or geophysical activity. Plans are underway for resuming operations early in 1956.

Only refinery of any size is A/S Oileraffinaderi at Kalundborg.

SOUTH AMERICAN YEAR BOOK

The most complete directory and year book available on South and Central American oil companies and operations has just been published by E. Ospina-Racines, a leading economist.

The volume, called "1956 Oil Directory of Key Personnel in South America and Year Book," covers these 14 countries: Trinidad, Venezuela, Colombia, Ecuador, Peru, Bolivia, Chile, Brazil, Argentina, Cuba, Aruba, Curacao, Uruguay, Guatemala.

For each one, these data are given: Government Oil Officials; Oil Operators, Exploration, Producers, Refiners, Marketers, Pipe Line; Service Companies; Contractors; Names of Firms; Key Personnel, post; Addresses, Cable; Airmail; Telephones; Warehouses.

Also included is operational information such as: Oil production, rigs active, footage drilled, completions, refinery capacities and runs, reserves, etc.

(Price $15. Write E. Ospina-Racines, Apartado Aereo 49-45, Bogota, Colombia).

ECUADOR

Prod. 9600 b/d **R. C. 6050 b/d**

Biggest news in Ecuador is announcement that Anglo-Ecuadorian Oilfields, Ltd., through a new producing and refining contract, proposes to build a plant in the country to meet growing demands.

Only refineries at present are Anglo-Ecuadorian's plant at La Libertad (5600 b/d) and Manabi Exploration Company's (Pantepec) 450 b/d plant at Cautivo.

Present refinery runs are about 4800 b/d and products are imported to make up the 5500 b/d demand. Much of this is gasoline. The government has put price controls on local refined products sales which has held back refinery expansion.

Ten rigs are operating in the country. Manabi made a second discovery on its San Raimundo concession.

California (Standard of California) Ecuador Petroleum carried on field geological investigations over its 3-million-acre concession on the coast.

EGYPT

Prod. 45,000 b/d **R. C. 66,000 b/d**

Sahara Petroleum (formerly Egyptian-American Oil Company which Egyptians could not pronounce) spudded its first test 28 miles southwest of Alexandria in May on a 50-million-acre concession in the west desert granted Conorada and Cities Service. Well had reached 10,000 ft at end of year. Oil shows were found at 5700 ft in the basal Eocene. A second rig was unloaded in October for a test 60 miles southwest of Bax No. 1. This makes 6 rigs in the country.

Subsidiary of Continental Oil Company, Sahara Petroleum is operator for a group of subsidiaries of Continental, Ohio Oil, Cities Service and Richfield Oil. The contract with the Egyptian government calls for a minimum expenditure of $3 million during the first 3 years. In 1955 one gravity crew, 3 seismic crews, and 8 service parties worked on this concession.

Most important discovery is in the Balaim area on the Sinai peninsula. Each of three wells there had initial production of more than 1000 b/d. Southern California Petroleum is operator here for International Egyptian Oil (Petrofina, AGIP, Southern California and Swiss interests).

Anglo-Egyptian Oilfields, Ltd. (Royal Dutch-Shell) has applied for new exploration licenses in Egypt. These are in the northeastern part of the Nile delta, which contains sedimentary formations but has not so far been explored for oil. This company has Ras Gharib field.

The political climate and restrictive petroleum laws have hindered exploration and development. Refining has remained static for several years but now the government is building a 46,000 b/d plant near Cairo and has expanded its Suez plant to 26,000 b/d. Anglo-Egyptian has a 40,000 b/d refinery at Suez.

Consumption has risen steadily to about 75,000 b/d and is a heavy drag on balance of exchange. Use of kerosine is subsidized by the government and is expensive to the budget.

ETHIOPIA

Sinclair Petroleum Company drilled six exploratory wells in the Ogaden area.

FINLAND

Contract has been let by Neste O/Y a state oil company for an 18,000 b/d refinery at Tupavuori, near Turko, southwest Finland. Lumus Company will construct the $17 million plant. Machinery and equipment are being shipped from France and Germany.

Imports, principally from USSR and Romania, rose to 50,000 b/d, more than

double last year. The increase is mostly heavy oils.

FORMOSA (Taiwan)

Prod. 65 b/d **R. C. 18,500 b/d**

Exploration surveys by the Chinese Petroleum Corporation were continued during 1955 with seismic surveys and full-scale operation of a micropaleontological laboratory, undertaken for the first time in Taiwan.

Owing to financial limitations, exploration drilling was reduced and only two exploration wells were completed during the year.

Since no development drilling was undertaken, production for 1955 still remained low at 23,557 bbl of crude, 3776 bbl of natural gasoline, and 1,006,751 MCF of natural gas; of this total, 41% of the crude and 13% of the natural gas were contributed from the testing of exploration wells completed during the past two years.

The Chinese Petroleum Corporation's (Nationalist state oil company) 6500 b/d TCC unit is being constructed by Fluor Corporation at the Kaohsiung refinery.

FRANCE

Prod. 24,000 b/d **R. C. 610,000 b/d**

Some improvements were made in France's archaic petroleum laws during the year but the needed overhauling job was evaded.

Exploration has been intense and expensive throughout France. Socony-Vacuum Francaise and Societe Francaise des Petroles BP entered the field with search permits. Some 21 geophysical crews were busy most of the year and 45 rigs drilled 94 wells of which 30 were producers.

Parentis was shaping up into a fine field in Bordeaux. Discovered in 1954 by Esso Standard Societe Anonyme Francaise (Jersey Standard 52%; Gulf 18.35%; French interests 18.45%) the field, partly under a lake, is in the Aquitane Basin. Out of 15 wells drilled 12 were producers. Production at Parentis averaged about 12,000 b/d in 1955.

Esso made another discovery in 1954 at Mothes, the first well producing about 400 b/d. PREPA found oil shows near Mulhouse, Haut Rhin, and is making a seismic survey before further drilling. This company also discovered oil near Hagenau, Bas Phin.

Soc.des Petroles d'Aquitaine hit shows at 14,187 ft in the Lacq area.

In the Parisian Basin some indications of oil were found near Mailly. A small discovery was made at Donan.

Present refinery expansion will bring total crude capacity to about 650,000 b/d. Crude oil for the average 53,000 b/d throughput comes principally from the Middle East where France has some 200,000 b/d production.

At Dunkirk BP is constructing a bitumen plant with a capacity of 500 to 700 t/d. Antar Petroles de L'lAtlantique new refinery for 10,000 b/d at Donges, France will include a Houdriformer and a Udex unit. Hydrocarbon Research, Inc., is performing the engineering and the construction will be handled by the company under supervision of Hydrocarbon Research.

FRENCH EQUATORIAL AFRICA

Bureau de Recherches de Petrole (French-Government controlled) reports its 2 rigs drilled 8 wells in the Gabon Basin, which has many salt domes. Oil deposits are reported in the region of Port Gentil.

FRENCH WEST AFRICA

Afrique Occidentale Francaise has one drilling rig operating in this area and three exploration crews.

At Dakar, a petroleum wharf was built at a cost of more than $1 million, giving another indication of growing demand in all corners of the earth.

GAMBIA (British)

Exploration was begun in Gambia, the small British protectorate on the west coast of Africa where BP has a permit. A seismic crew is working.

GERMANY (East)

East German government has an exploration program in process. No reliable reports from this Communist section.

GERMANY (West)

Prod. 61,200 b/d **R. C. 300,000 b/d**

In the past year West Germany has further stepped up its crude oil production. The daily average mentioned above was 10,000 bbl higher than in 1954. The total annual output for the first time surpassed the 20 million barrels mark.

Of the total production 35.7% came from the Emsland district, 35.5% from the area round Hanover town. The remainder falls to the account of the Weser-Ems district, the Holstein province, the Upper Rhine Valley, and Bavaria.

With 2,408,000 ft the oil companies active in Germany could again record an extraordinarily high total drilling footage. No less than 577,000 ft of this total were wildcat wells and 390,000 ft extension wells. Several fields were discovered. The most prolific new fields are Landau in the Upper Rhine Valley, Lueben in East Hanover, Vestrup in the district between Weser and Ems, and Kiel in Holstein.

To cover the local demand a quantity of 66 million barrels of crude oil had additionally to be imported to West Germany in 1955, mainly from the Middle East. While the German oil imports increased by 31%, the export trade with finished products from German refineries was stepped up by 47%.

The German refineries treated 228,000 b/d in the preceding year, having a throughput capacity of about 300,000 b/d at the end of 1955. A main expansion of the refineries is expected for the future. Standard Jersey, Shell, Mobil Oil, and the hydrogenation works of Gelsenberg announced projects for the addition of further treating capacities.

Remarkable is the progress of natural gas production in the country. The output trebled in the course of 1955, amounting to 8.5 billion cu ft annually at present. Nearly one-half of this quantity came from the gas field Rehden in the Weser-Ems district.

GOLD COAST

At the end of the year Gold Coast Gulf Oil Company (Gulf Oil) was negotiating with the Gold Coast chiefs and government of the Gold Coast (Africa) for an oil exploration license. A land concession agreement was signed at Beyin February 3, 1956. The agreement authorizes the company to explore for and develop mineral oil deposits which it might discover in an area approximating 100 square miles, in the Western Nzima State, for a term of 99 years. A separate 99-year lease agreement between the Gold Coast Government and the company, covering approximately 100 square miles of the adjacent seabed was also signed.

GREECE

The Greek Government 30,000 b/d refinery in Aspropyrgos is scheduled for completion in mid-1957. Hydrocarbon Research, Inc., is performing the engineering and George Armistead & Company are technical advisors. Three German firms are participating in the construction, Hydrocarbon Mineraloel GmbH, Fried. Krupp Maschinen und Stahlbau Rheinhausen, and Stahlunion Export, GmbH. This refinery will include atmospheric and vacuum distillation, Atlantic catforming, asphalt, and sweetening units.

At present consumption is 24,000 b/d of oil products. Two rigs are operating.

GUATEMALA

The new petroleum law, which went into effect in August has attracted a number of exploration applications.

Exploration rights will now be granted for 6 years with 2 renewal periods of 2 years, and exploitation rights for 40 years, renewable for a further 20. The provisions provide for a form of 50/50 division of profits with 27½% depletion.

Texas Company and Richmond have been working under preliminary permits, Conoco, Ohio and Amerada did some photogeologic work and surface reconnaissance mapping projects before making application for concessions in Peten Province, near Mexico's Isthmus production. Atlantic, Shell, Union of California, Jersey Standard, Standard of Ohio and Standard of California are among the other 30 to 35 applicants for "rights."

HAITI

Mark Edwin Andrews, Houston, Texas, (et al) is drilling on the exclusive oil concession in Haiti held by Commonwealth Oil Company. The second well on Isle de Gonave in Port-au-Prince Harbor, is scheduled for 8000 ft. The first hole was abandoned.

HAWAII (U. S. Territory)

R. C. 3000 b/d

Standard Oil of California purchased the Honolulu refinery from Pacific Refiners in September. The LPG portion of the business was sold to Honolulu Gas Company.

Meanwhile Standard awaited final action by the Territory on a proposal to construct a 25,000 b/d refinery.

HONDURAS (British)

The British Honduras Gulf Oil Company spudded its first wildcat test, Yalbac No. 1, on June 20, 1955 and at the end of the year was at 6633 ft. The test is approximately 48 miles southwest of Belize.

John L. Sullivan, president of Texon Drilling, heads a new firm, Compania Petrolera Hondurena, which was granted a 20-year concession in north Honduras. A drilling site has been selected about 185 miles east of Trujillo.

John W. Mecom and Ernest Cockrell, Jr., have acquired an 85 per cent interest in 50 million acres on north Honduras and offshore and plan to drill.

This will make three rigs in the Central American country.

HUNGARY

Prod. 25,000 b/d? **R. C. 40,000 b/d?**

Production from Zala area is reported to be still rising. Oil was discovered here by a Jersey Standard company shortly before World War II and has been developed since 1948 by a national monopoly. Information is meager from the communist nation, of course.

INDIA

Prod. 6920 b/d **R. C. 73,600 b/d**

Seismic exploration is continuing in the Bengal Basin concessions granted Standard-Vacuum in 1954.

At the beginning of 1955, the Assam Oil Company (Burmah Oil) had two seismic parties assisted by helicopters working in Upper Assam.

In spite of repeated severe flooding, construction work on the approach road and site for a test well by Assam Oil at

Moran, 25 miles southwest of Nahorkatiya, was proceeding satisfactorily at the end of the year.

Of the 10 wells completed at Nahorkatiya by the end of the year, 6 were commercial producers. This 35 API oil is from Oligocene sandstone at approximately 10,000 ft. The field is connected to Assam's refinery at Digboi by a 23-mile, 8-in. pipe line.

Production drilling continued throughout the year, both in the older part of the Digboi oilfield and the eastern extension.

Total production for 1955 by Assam Oil from Digboi and Nahorkatiya, the only producing fields in India, amounted to 2,526,000 bbl or 6920 b/d. This compares with a 6120 b/d for the previous year. Eight rigs were operating.

Stanvac is engaged in exploration in India.

Burma-Shell's 40,000 b/d refinery at Bombay (*Petroleum Engineer*), January 1956, Page C-21) went into operation in 1955. It is India's largest refinery; was built at a cost of more than $64 million.

Crude capacity of Standard-Vacuum's Bombay refinery went to 30,000 b/d from a mid-1954 rate of 25,000 b/d. A polymerization plant is scheduled for completion in the first half of 1956.

Work has begun on the construction of a 13,500 b/d Caltex refinery at Vizagapatam, India, which is expected to go on stream early in 1957.

INDONESIA

	Prod. b/d	R. C. b/d
Sumatra . . .	204,000	160,000
Java	12,386	7,800
Borneo	17,000	56,000
	233,386	223,800

There appears to be a hope, at least, that Indonesia will throw off Communist agitation and settle down. Stanvac's 4-year $70-$80 million investment program is evidence of this faith. Caltex is developing its Sumatra production and Royal Dutch-Shell, which has the most property in the Republic of Indonesia islands, has continued to expand despite nationalization of its North Sumatra properties.

Drilling rigs in operation are 26.

IRAN

Prod. 340,000 b/d **R. C. 572,000 b/d**

Operations in South Iran during 1955 proceeded in accordance with the 1954 Oil Agreement between the Iranian Government, the National Iranian Oil Company, and the Consortium.

Total net crude production of the Iranian Oil Exploration and Producing Company (within area covered by the Agreement) for the year amounted to 117,659,120 bbl or about 322,000 b/d. In December, 1955 average was 340,000 b/d. Over 70 per cent of this production came from the Agha Jari field, 100 miles northeast of Abadan where a new production unit with a capacity of 157,000 b/d was put into operation.

No field geological or seismic work was undertaken during the year, neither was there any drilling.

The Iranian Oil Refining Company's throughput at Abadan Refinery amounted to 145,600 b/d in 1955. The capacity figure above includes Abadan's prenationalization throughput. Only other refinery is 2300 b/d Kermanshah plant operated by Iranian Oil Company, the state monopoly. No new facilities were completed but major overhauls were carried out on a number of units.

In addition to the 8 companies in the Consortium, 9 new companies formed Iricon Agency to take over 5% interest. They are: American Independent, Atlantic, Hancock Oil, San Jacinto Petroleum, Signal, Standard (Ohio), and Tide Water Associated.

Iran consumes about 17,000 b/d of its oil. It is distributed by National Iranian, which plans a 590-mile, 10-in. products line from Abadan to Tehran.

Payments for the first 11 months to the Iranian Government from the Consortium were more than $98 million.

Exploration drilling in Central Negev of Israel. *Israel Office of Information*

IRAQ

Prod. 667,400 b/d **R. C. 42,750 b/d**

Iraq Petroleum drilled 3 wells at Bai Hassan and 4 wells at Jambur with its 6 rigs. At the end of 1955, Kirkuk had 44 producers and 18 being tested. The company constructed a 36-mile 20-in. pipe line connecting Jambur, a new field discovered in 1954, and Kirkuk put up a temporary de-gassing station at Jambur.

Basrah Petroleum brought in 8 new wells with 2 rigs at Rumaila, making a total of 13 producers.

Mosul Petroleum was operating 4 rigs, at Jebel Makhul, Sasan, Atshan and Alan. Khanaqin Oil (BP) produced about 13,000 b/d from the Naff Khaneh field.

Altogether 12 rigs are in Iraq.

Iraq's consumption has risen to about 20,000 b/d.

The Iraqi Government has established an Oil Affairs office in London. Receipts from Iraq Petroleum and affiliates on a 50/50 profit sharing basis were $202 million, 6% higher than in 1954.

IRELAND

R. C. 600 b/d

A new refinery to be built jointly by Esso, Caltex, and Shell is proposed. Irish Minister of Industry and Commerce William Norton, announced that plans have been received and are under examination.

A private group has made inquiries about exploration for oil and gas.

ISRAEL

Prod. 420 b/d **R. C. 85,000 b/d**

At the end of 1955, Israel's first discovery well, brought in on September 23, 1955, was producing at the rate of 420 b/d from 4965 ft on a 5/16-in. choke.

The crude was being transferred to Haifa where it is being stored pending accumulation of sufficient quantities for refining. The Haifa refinery of Consolidated Refineries, Ltd., with its 85,000 b/d capacity, was running at about 25% of its capacity throughout 1955 on crude from Venezuela and Eastern Europe.

Following Israel's first oil discovery, exploration activities were greatly increased by the 8 licensees holding a combined total of 38 exploration permits covering some 2,800,000 acres, or 54% of Israel's entire land area. The 8 licensees represent local and foreign investors, including United States, Canadian and Swiss individuals and groups. Five rigs were running at the end of the year.

In the immediate vicinity of the discovery well, a few miles inland from the Mediterranean coast near the Gaza Strip, two step-out wells were being drilled and additional drilling was scheduled to determine the size of the field. (One offset came in March 8, 1956.)

Other wells were proceeding at year's end in two locations in the central Negev (Israel's southern desert) and another deep test was under way a few miles southeast of the discovery well.

ITALY

(Also see Sicily and Trieste)

Prod. 4310 b/d **R. C. 451,000 b/d**

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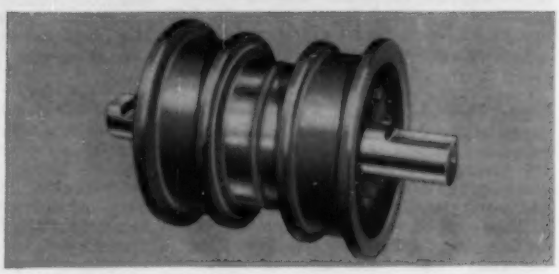

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(U.S. News & World Report, March 9, 1956).

Operations are hindered by failure of the Italian Parliament to enact oil legislation permitting private companies to develop any discoveries they make. At the present time Ente Nazionale Idrocarburi has a virtual monopoly in the Po Valley and even the new petroleum bill limits all applicants except ENI to 741,000 acres (outside the Po Valley).

Petrosud (Gulf Italia 50%, Montecatini 50%) holds several research permits on the Adriatic Coast of Italy. In January 1955, Petrosud's wildcat Cigno No. 1 came in for an initial production of 1850 b/d of 34 API oil on ⅜-in. choke. Cigno No. 2, 500 miles north of the discovery well, was carried to 7946 ft as a test of deeper horizons and has been temporarily abandoned. At year's end, wildcat Tortoreto No. 1 was drilling at 7011 ft. No development drilling was carried out at Cigno since as yet a producing concession has not been granted by the Italian Government.

Mofag (see Switzerland) and Snia-Viscosa, an Italian rayon firm, have a 50-50 interest in 2 Italian concessions, which the latter obtained before the Gulf discovery.

Geological and geophysical surveys have been made and a first 5000 ft test scheduled on the 125,000-acre Sangro concession near Abruzzi in Central Italy.

D. D. Feldman Oil & Gas, Dallas, Texas, has applied for a concession on the West Coast.

ENI, state-owned concern, has developed natural gas in the Po Valley and has piped it to many large cities. Production in 1955 ran about 350 million cu ft a day with reserves estimated at 90 billion cu ft.

There were 34 rigs operating in Italy.

Refinery runs were well below capacity, about 350,000 b/d. Italy consumes some 165,000 b/d and the remainder is exported. High local tax has depressed refining activity and product sales.

The Porto Marghera refinery, Venice, owned by BP and Azienda Generale Italiana Petroli, will have the first platforming unit in Italy.

JAMAICA

Base Metals Mining Corporation, Ltd., a Canadian firm, drilled to 6300 ft in the Negril area and got shows of oil. Since then, Jamaican Stanolind Oil Company, a subsidiary of Stanolind Oil and Gas Company, has taken over the exclusive oil and gas prospecting licenses formerly held by Base Metals, with the latter company to receive a 25% interest in any production that may be developed. The licenses cover all land and offshore areas in Jamaica.

Jamaican Stanolind will spend $2 million on geological and geophysical work and in wildcat drilling prior to June 21, 1958. First well to be drilled by Jamaican Stanolind will probably be started by May 1. Associated Noble Corporation, Tulsa, Oklahoma, will be the drilling contractor.

JAPAN

Prod. 6016 b/d **R. C. 297,900 b/d**

Restriction of using heavy oil kept the consumption about 190,000 b/d. Of this amount 148,000 b/d was refined domestically and 41,000 b/d was imported.

Refining capacity was increased about 80,000 b/d in 1955. Total facilities amount to 297,000 b/d. Additional facilities were built by Nihon Kogyo (Funakawa), Kowa Oil (Marifu), Toa Nenryo (Wakayama) and Maruzen (Shimotsu).

Nippon Oil Refining (Yokohama) and Showa Oil (Kawasaki) are constructing additional distillation plants.

Production is guarded zealously but potential is restricted. For this purpose Japan Petroleum Exploration, half-owned by the Japanese Government, was established in December 1955 to execute a vast exploration program within Japanese territory. It is planning more extensive geophysical exploration on the alluvial plains including offshore work.

More than 98% of domestic production was produced by the Teikoku Oil Company. No new field was discovered in 1955 except southern extension of the Yabase field, Akita Prefecture, which produces 64% of TOC's total production.

JAVA (Indonesia)

Prod. 12,386 **R. C. 7800 b/d**

Two small Shell refineries here.

Kawengan field in the Rambang area produces 11,700 b/d and Kuka field in the Surabaya area produces 686 b/d.

(See Indonesia.)

JORDAN

In Jordan, an American oil producer has been granted government approval to do preliminary exploration work for the next eight months. At the end of this time, Edwin W. Pauley Los Angeles, California, has permission to select up to one-third of the kingdom for drilling and development. The agreement stipulates that all profits will be shared 50-50 with the government after exploration expenditures have been regained.

KENYA

Shell Overseas Exploration and D'Arcy Exploration have licenses in this East African country and are conducting some exploration surveys.

KUWAIT

Prod. 1,091,763 b/d **R. C. 30,000 b/d**

Crude oil production in 1955 was 398,493,597 bbl of which 386,398,003 bbl or 1,058,625 b/d were exported. This is the largest production in the Middle East.

Kuwait Oil Company's (Gulf & BP) wildcat well at Raudhatain in North Kuwait, which was commenced in 1954, was completed in November 1955 at a depth of 10,301 ft. Tests showed that there was a considerable productive zone in the well, but the extent of the reservoir can only be determined by further exploratory drilling. A second well has been spudded in 1.8 miles southeast of the discovery.

During 1955 five rigs drilled 21 development producers and 1 dry hole.

Crude oil handling facilities were increased during the year by the extension of one 20-in. transit line and the installation of an additional transit line of 30-34-in. to handle throughput of crude from the Burgan field to Ahmadi storage.

Plans are made to increase the size of the refinery at Mina al-Ahmadi from 30,000 to 170,000 b/d by the end of 1957 to meet the increasing local consumption of products and to increase availability of bunker fuels. Two distillation units will be added, storage tanks and equipment to increase refinery services such as power steam and water supply. Present runs average 29,445 b/d.

The two units will be designed by E. B. Badger & Sons, Ltd. (which built the existing refinery). The erection of the units and all other facilities will be engineered and constructed by Bechtel International in association with George Wimpey and Company, Ltd., which previously carried out contracts for the company in Kuwait.

KUWAIT-SAUDI ARABIA NEUTRAL ZONE

Prod. 31,000 b/d

In the Kuwait-Saudi Arabia Neutral Zone, American Independent Oil Company and Pacific Western Oil Corporation completed and put on production 12 wells in the Wafra Field during 1955. Two exploratory wells were drilled to projected depths but were dry and abandoned. Four rigs were used.

At the end of 1955, there were 29 producing wells in the Wafra Field. The total production for the year was 8,847,769 bbl or an average of 24,250 b/d. Production is currently at the rate of 31,000 b/d. Total cumulative production is 14,835,447 bbl. Tests of the shallow limestone pays and the recently discovered Ratawi zone will have additional drilling tests this year.

Facilities for handling and shipping crude oil in the Kuwait Neutral Zone have been increased, with Pacific Western building a gathering center and a pipe line to the marine terminal, Mina Saud. The submarine loading accommodations at Mina Saud have been in use since February 1955.

LEBANON

R. C. 20,550 b/d

Lebanon receives considerable revenue for transit of Iraqi and Saudi Arabian oil in pipe lines across its territory and through its port of Tripoli. The Government expects still greater revenues in new contracts now under negotiation.

Two refineries on its coastline are Iraq Petroleum's Tripoli plant, which runs 11,550 b/d and Mediterranean Refining (Caltex and Socony) Sidon plant which was recently expanded to 9000 b/d capacity.

LIBYA

As soon as Libya's new and reasonable petroleum law went into effect in July, 1955 there was a flood of applications to explore this North Africa kingdom. The country is divided into 4 zones and concessions are limited in each zone.

Among the concession holders are: A Socony Mobil affiliate, which has 11½ million acres and has applied for 5 million more; California Asiatic Oil Company (Standard of California), and Texaco Overseas Petroleum (Texas Company) which have a 50-50 interest in concessions covering approximately 14,000,000 acres in Cyrenaica and Tripolitania; D'Arcy Exploration Company (Africa), a BP subsidiary, with three concessions totalling about 3½ million acres in Cyrenaica and one concession of about 4½ million acres in Tripolitania; Continental, Ohio and Amerada, with concessions covering 38 million acres operated by Ohio Oil Company (Oasis); Texas Gulf, Royal Dutch-Shell, Esso Standard, Francaise des Petroles, Bunker Hunt.

There will be active exploration and drilling in 1956.

MADAGASCAR

Three geological crews and one geophysical party operated in this island off East Africa in 1955. One drilling rig has been in operation for Societe des Petroles de Madagascar.

MALTA

D'Arcy Exploration Company (BP) carried out a geophysical survey and began a 3-well drilling program with one rig. A palaenthological laboratory has been established and specimens are being evaluated.

MEXICO

Prod. 252,000 b/d **R. C. 333,000 b/d**

In spite of the steady growth of inland consumption, Mexico manages to fill demand and export more crude oil and oil products than it imports. Consumption averages more than 200,000 b/d.

Drilling in 1955 went over the 365

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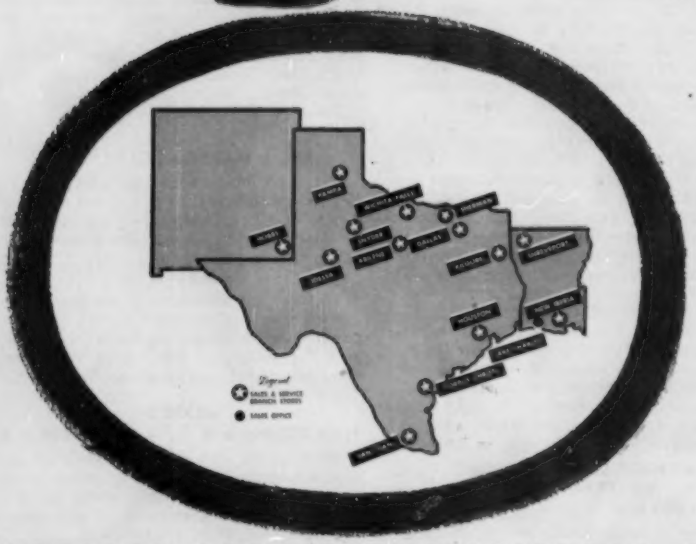

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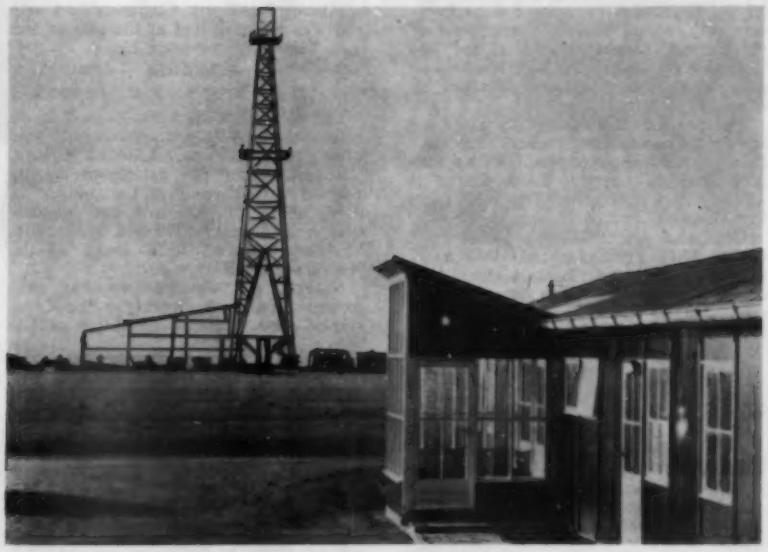


A new derrick in the Western Holland and Shell offices at Rijswijk. Shell Photo

wells Petroleos Mexicanos planned and the 1956 program is set at 750 wells, more than twice the 1955 number. There were 94 drilling rigs at the end of 1955. Managing Director Antonio J. Bermudez has set 500,000 b/d as a production goal for 1958.

New producing areas account for the increase in output, mostly in the Golden Lane in Veracruz.

Highly important at this time is the possibility of exporting natural gas to the U.S. from North Mexico. Another gas line from Renosa field to several cities, including Monterrey is proposed.

Pemex has considerable refining expansion completed this year or being constructed. A new cat cracking plant and fluid coker are being built at Ciudad Madera refinery, capacity is to be increased from 78,000 b/d to 100,000 b/d. A thermal cat cracker at Minatitlan was almost completed at the end of 1955.

Capacity at the Atzcapotzaico refinery was almost doubled recently to 112,000 b/d and an 18-in. pipe line was completed from there to Mexico City.

A 4-in. liquid propane line from the Poza Rica field is under construction to supply increasing demands there.

The Tampico refinery was increased to 10,000 b/d and a 300-mile pipe line is being laid from there to Monterrey. Expansion at the 32,000 b/d plant in Minatitlan was completed early in 1956.

MOROCCO (French)

Prod. 2110 b/d **R. C. 4500 b/d**

Societe Cherifienne des Petroles, French government oil concern, continues to develop the area around Petitjean, where the refinery is, Objective is to obtain enough production to use the full capacity of the refinery. Now refinery runs are about 2100 b/d.

Four seismic parties are working and seven rigs are operating. In the Rharb-Preif Basin three tests discovered new fields and 21 were dry holes. Five field wells are producers. One wildcat in the Moulouya Basin was dry.

Morocco imports about 17,500 b/d oil products.

MOZAMBIQUE

Gulf Oil Corporation continued seismic work throughout the year on its concession in this Portuguese territory in East Africa.

No drilling was undertaken but plans were made to resume drilling in 1956 with the one rig in the area.

NETHERLANDS

Prod. 24,500 b/d **R. C. 230,000 b/d**

A new oil-producing area has made 1955 a year of new oil hope for the Netherlands. Near the Hague in the west, several small fields, one gas and two oil, have been found. Nine rigs are operating in Holland.

Production of oil and gas is in the hands of N. V. Nederlandse Aardolie Maatschappij (NAM) jointly owned by Royal Dutch-Shell and Jersey Standard. Largest production is still at Schoonebeek field in the northeast. Its output rose slightly in 1955.

Caltex is adding a 4000 b/d distallation unit and a 7000 b/d platformer at its Pernis refinery.

Royal Dutch-Shell Pernis plant, largest in Europe (200,000 b/d), will build the first synthetic glycerol plant outside the U. S.

NETHERLANDS ANTILLES

R. C. 675,000 b/d

Aruba. Lago (Jersey Standard) refinery has 440,000 b/d capacity and a throughput of about 400,000 b/d. Shell's refinery (35,000 b/d) is shut down.

Curacao. Shell's 200,000 b/d crude capacity refinery here is running 289,000 b/d including crude oil intake to cracking plants. A new 35,000 b/d catalytic cracking plant is planned and is expected to be in operation within two years.

NEW CALEDONIA (French)

A well drilled in New Caledonia, in the South Pacific, by the Societe de Recherches et d'Exploitations de Petrole en Nourvelle-Caledonie had slight showings of oil.

NEW GUINEA (Neth.)

Prod. 9100 b/d

NNGPM, a company owned by Shell (40%), by Standard-Vacuum (40%) and by Caltex (20%) is developing the three fields in West New Guinea, a territory of the Netherlands. One rig is used. The largest field, Klamono, has 18 API crude but the other two produce light 45 API oil.

NEW ZEALAND

Prod. 40 b/d **R. C. 80 b/d**

Shell and BP are carrying out a $3 million oil exploration program in North Island on concessions of Todd Oil Services, Ltd. They have one drilling rig.

Only production, after years of exploration and drilling in New Zealand, is a 5-well field at New Plymouth. This does not go far toward the 25,000 b/d demand.

NICARAGUA

Cuban Oil Resins, Inc., has been granted an exploration license covering the entire Central American country for three years.

NIGERIA (British)

Some $34 million is said to have been spent in 18 years on exploration in this West Africa territory with little success to date. Shell D'Arcy Petroleum Development of Nigeria (Shell and BP) had the only concession until late 1955 when Socony-Vacuum was given a license over the north part. One rig is in use.

Shell-D'Arcy drilled a wildcat near Benin City to 6000 ft with slight oil shows. It is now drilling at Ahuhwa in East Nigeria.

NORWAY

R. C. 2000 b/d

It is reported that the Norwegian government is negotiating with a large oil company about the building of a refinery in East Norway. A capacity of 40,000 to 50,000 b/d is proposed at a cost of $56 to $70 million.

The present plant at Vailoy (Esso) runs Venezuelan crude and its main products are solvent, lubes and asphalt.

OMAN (and Muscat)

At the end of December Petroleum Development (Oman) had a rig at Fahud and expected to spud in the first of 1956. This Iraq Petroleum affiliate also surveyed the southeast coastal region of Muscat (on east tip of Arabian peninsula).

During the year, Dhofar-Cities Service, a subsidiary of Cities Service, continued geological work that was begun in 1954 in Oman. In addition, the first exploratory well was drilled near the close of the year with no commercial production. A second test is now under way at another location.

PAKISTAN

Prod. 5670 b/d **R. C. 5400 b/d**

Seismic survey operations for Pakistan Petroleum Ltd. in Khairpur area of West Pakistan were suspended in May. Resumption of the work in November was preceded by seismic surveys at Kot Sarang and Pira Jangla in the Punjab Province. Gravity surveys for Pakistan Petroleum in the central part of East Pakistan continued until June and were resumed in November.

A test well in Sylhet in East Pakistan caught fire in June; later the fires died out of their own accord. Pakistan Petroleum is preparing for a second test well at Sylhet. At Uch near Sui in West Pakistan, a test well by Pakistan Petroleum was dry and abandoned at 11,000 ft. Gas was produced during testing operations.

The Karsal test well by Pakistan Oilfields Ltd. (Attock Oil) was still drilling at the end of the year. Its test at Bains was abandoned at 11,135 ft. Attock Oil's deep test in its Khaur field was unsuccessful. Eight rigs were used during the year.

At the present time the only producing oilfields in Pakistan are in Potwar, West Pakistan. Total oil production in Pakistan in 1955 including Pakistan Petroleum's

share of production from Balkassar amounted to 2,068,000 bbl, about 5670 b/d. Cumulative production at the end of 1955 was 21,800,000 bbl.

The 348-mile, 16-in. pipe line from the Sui Gas field to Karachi was completed and supplies to consumers began in September. Another 400-mile, 16-in. line from Sui to Lahore is proposed. Sui gas reserves are estimated at 4½ trillion cu. ft.

Agreements between N. B. Hunt, C. L. Hunt and the Governor-General of Pakistan to explore 20,000 sq miles were signed in Washington in September, 1955. Equipment for exploration and drilling has been shipped to Karachi.

Standard-Vacuum is shipping a modern drilling rig and prefabricated camp to Karachi also hoping to "spud in" its first exploration well in the Indus Valley about 10 miles from Jhudo.

PAPUA (New Guinea)

Australasian Petroleum and Island Exploration (both owned by BP, Stanvac, and Oil Search Ltd., and Australian organization) continued exploring for petroleum in the Australian Territory of Papua throughout 1955. These two companies have spent an estimated $37 million exploring this territory.

Field parties carried out 27 party months on geological surveys; 25 party months of seismic surveys, one party being serviced by helicopters, and 12 party months on gravity meter surveys. In addition a hydrographic survey of coastal waterways proceeded over most of the year.

During the year three wells, Island Exploration's Omati No. 1, Omati No. 2 and Aramia No. 1 were drilling. Omati No. 1 was drilled to 14,352 ft and, after testing was abandoned. Omati No. 2 was suspended at 10,880 ft following the evidence from No. 1 on absence of any production within reasonable drilling depth. Aramia No. 1, spudded-in during April, was completed at 6628 ft in basement granite and after testing of several horizons also abandoned.

At the year end Australasian Petroleum's Kuru No. 1 well was about to spud-in. Four rigs are in the country.

Papuan Apinaipe Company and New Guinea Gold and Petroleum Development Company hold prospecting licenses in Papua.

PERU

Prod. 47,000 b/d **R. C. 47,200 b/d**

If you want to buy regular gasoline for 10 cents a gallon, you can find it in Peru. This is one big reason that consumption has slipped ahead of production.

Exploration parties number 13 and rotary rigs in operation are 22. Oil is found in the extreme West Coastal Zone, known as Sechura Desert and in the Eastern Zone.

Peruvian Gulf carried out some surface work in the Sechura Desert and undertook some office photogeological work over the area of its Oriente Zone concessions.

Douglas Oil Company successfully completed a deep test in the Lobitos area of Peru on the coast. The well came in flowing 720 bbl of 39 deg oil through a 18/64-in. choke. It was directionally drilled under the ocean from onshore location and was completed in the Basal Salinas zone in an interval between 6896-6963 ft.

Perovian Pacific Petroleum (Cities Service) drilled 4 wells in its holdings on Empresa Petrolera Fiscal (government-sponsored oil company) lands. One of these wells was completed as a producing oil well. Petrolera Peruana, S.A., a Peruvian firm, found oil in the northwest of the Sechura Desert at 4200 ft for 500 b/d. This is close to the La Brea-Parinas area on the coast, largely operated by Jersey Standard.

The Texas Company is drilling in Eastern Peru close to San Lorenzo. (See Page B-36.) It holds a concession over 2.5 million acres in eastern Peru where it spudded-in a well about 2½ miles from San Lorenzo.

Compania de Petroleo Ganso Azul (Texas Gulf Producing) has laid a 45 mile 4-in. pipe line from Ganxo Azul oilfield to Paucalipa on an Amazon tributary, Ucayali River.

Skiles Oil, Mt. Carmel, Illinois has been granted a 500,000-acre concession on the east slope of the Andes.

PHILIPPINES

R. C. 13,000 b/d

The Government has granted 26 exploration licenses to 4 companies and has applications for several more.

Standard-Vacuum obtained 8 concessions of approximately 950,000 acres in exploration concessions in the Cagayan Valley of northern Luzon and is preparing to undertake a geological survey of the area. Philippine Oil Development (local) has 10 concessions for 1,258,000 acres. Acoje Mining Company (local, Pantepec and Pancoastal Petroleum) has one 134,000 acre concession. Caltex (Philippines) Inc. has 7 concessions totalling 1,233,000 acres. California Asiatic Oil Company (Standard of California) acquired half interest in exploratory rights to 7 areas in Cagayan Valley.

The Philippine Bureau of Mines made extensive studies during the year. No drilling was done but two sites have been selected for 1956 drilling.

Stanvac is negotiating with the government for a 21,000 b/d refinery, which would cost about $35 million. Shell also has proposed a refinery in talks with the Philippines National Petroleum Council.

POLAND

Prod. 4500 b/d? **R. C. 5000 b/d?**

According to Poland's Six-Year Plan, ending in 1955, the country was reaching for 7900 b/d last year. From available reports, this is far from accomplished but considerable exploration effort appears to have increased production slightly and found new gas reserves. A number of gas lines are being built to use the increased production.

PORTUGAL

R. C. 25,000 b/d

A firm owned mainly by the Portuguese Government, Companhia Dos Petroleos de Portugal, has entered into a contract with Socony-Vacuum Exploration Company to share its interest in a concession in Portugal. Socony will handle exploration operations.

The one refinery at Cabo Ruivo has a throughput of about 16,500 b/d.

Consumption in Portugal has risen slightly to 16,580 b/d.

PUERTO RICO

R. C. 10,000 b/d

Caribbean Refining Company's (Gulf) 10,000 b/d plant near San Juan has gone on stream.

A 22,000 b/d refinery has been constructed by Commonwealth Oil Refining Company at Ponce on the south coast. Plans are to double capacity.

QATAR

Prod. 114,400 b/d **R. C. 600 b/d**

Production for 1955 was 41,768,258 bbl and total footage drilled was 54,720 ft.

Nine wells were drilled during the year by Qatar Petroleum Company and one well was being drilled at the end of the year. Three rigs are available.

ROMANIA

Prod. 170,000 b/d? **R. C. 160,000 b/d**

The Soviet has sold the Romanian oil industry back to Romania, probably under terms similar to those made with Austria.

Reports from the petroleum agency indicate a 10.5 million ton output in 1955, about 210,000 b/d but Moscow reports indicate 170,000 b/d production. New areas have forged ahead of the Ploesti region, it appears.

Natural gas development has progressed rapidly, according to the Communist press, reaching an output of 135 billion cu ft in 1955.

A Reuters release said that radioactive isotopes were being used to find oil. The report also states that wells in the Ploesti area go as deep as 22,965 ft and that Romania makes all its own oil equipment.

SAUDI ARABIA

Prod. 965,041 b/d **R. C. 198,000 b/d**

Arabian American Oil Company in 1955 produced 352,239,912 bbl of crude oil, the greatest in Aramco's history and exceeded the 1954 average by 12,000 b/d. Aramco's highest daily average to date for a calendar month was 1,041,098 bbl in November, 1955. Cumulative production of crude oil passed the two-billion-barrel milestone on February 20.

The Aramco refinery at Ras Tanura processed 74,171,745 bbl of crude oil during the year. Most important addition to the refinery's facilities was a fluid hydroformer, which went on stream in October. This catalytic reforming unit cost approximately $13 million and was the first such unit constructed in the Middle East. It is designed to produce 8700 b/d of 92 clear octane gasoline to be blended with other stocks.

Toward the end of 1955 the gas-injection plant at Abqaiq, which was opened in 1954, was compressing 150,000 MCF/d of gas and returning it to the Abqaiq reservoir. The proposed water-injection program for this reservoir was scheduled to go into operation in 1956.

Other new construction completed in 1955 included a second gas-oil separator plant in the 'Uthmaniyah area of the Ghawar field and an 800-ft extension to the north pier at Ras Tanura to provide two additional oil-loading berths and to permit the handling of supertankers. Among the construction projects begun in 1955 were the extension of the south pier at Ras Tanura and the building of a new permanent community, named 'Udhailiyah, to serve as a base of operations for the Ghawar field.

At the end of 1955, 154 wells, more than in any earlier year, were producing crude oil. During the year three new oil wells were drilled, two in the Safaniya field and one in Ghawar. At the year's end, 5 rigs were active: 2 in the 'Uthmaniyah area of Ghawar, one at Abqaiq, one at Abu Hadriyah, and one on remedial work at Qatif.

The bulk of the engineering work was completed for placing the Safaniya field in production in 1957. Eight offshore wells, lying beneath the waters of the Persian Gulf, are included in the initial program. Major construction was scheduled for 1956 on a GOSP, bulk plant, pump station and 140-mile pipe line, of 20 and 22-in. diameter, extending from Safaniya to Ras Tanura.

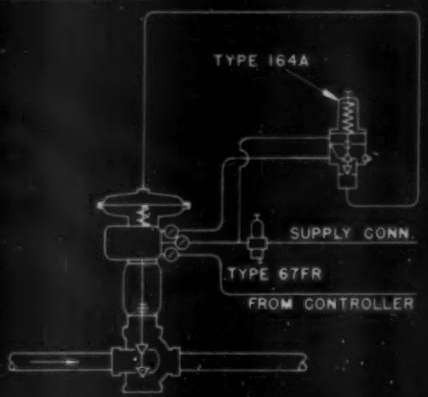
Eight exploration parties—one surface-mapping, one gravity-magnetic, 3 seismic and 3 structure-drilling — were operating

FISHER® SERIES 164

For "Gadgeteering" Control

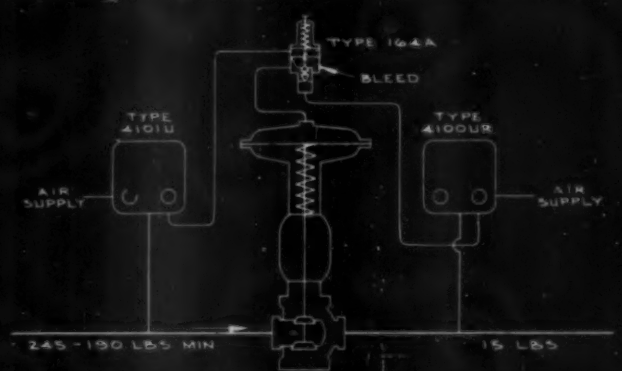
SUCH AS

TWO-WAY ACTION for SAFETY LOCK-UP



Lock-up system using Type 164A to close air circuit to diaphragm of main valve in case of plant air failure. Main valve will be held in position at time of supply pressure failure.

or THREE-WAY ACTION for SWITCH AIR CIRCUITS



Pressure reduction normally handled by 4100UR Wizard. If inlet pressure to main valve falls below a predetermined amount Type 4101U snap-acting Wizard bleeds pressure off Type 164A switching valve causing 3-way valve to change position so as to close control line pressure and bleed main valve diaphragm pressure to atmosphere. Main valve will stay closed until inlet pressure is restored to desired amount.

- SMALL
- COMPACT
- SELF CONTAINED

Side view of Type 164 Showing ½" Control Line Connection. Control Chamber is separate from body chamber.

SIZES ¼" or ½"

CONTROL SPRING RANGES PSI	PRESSURE CHANGE ON DIAPHRAGM FOR FULL VALVE STROKE, PSI
3 to 15	2
5 to 20	2½
5 to 35	4
30 to 60	5¾

MATERIALS

Zinc die cast body and spring case, composition diaphragm and valve disc.

FISHER GOVERNOR COMPANY
MARSHALLTOWN, IOWA
CANADIAN PLANT: WOODSTOCK, ONTARIO
WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

in the concession area at the end of 1955. Among the areas studied were the Rub' al-Khali, Northwest Concession Area, Gravel Plains, Central Coastal Area, and offshore regions. Structure-drilling units in the Rub' al-Khali worked as far as 620 miles from their base camp and were supplied by air.

SICILY

Prod. 2600 b/d **R. C. 40,000 b/d**

In the Ragusa field, owned by Gulf Italia Company, five wells were brought into production and two others had reached final depth at year's end, bringing to 10 the total wells drilled in the field. Total production from the field during 1955 was 954,075 bbl. Also in the Ragusa concession, wildcats Giarratana No. 1 (TD 7054 ft) and Chiaramonte No. 1 (TD 7400 ft) were completed as dry wildcats and Licodia No. 1 was drilling at 2350 ft at year's end.

In central Sicily, Mediterranean Oil Company (Gulf Italia, 65%—MacMillan 35%) completed Aragona No. 1 at 10,100 ft as a dry hole. Mediterranean also completed Comiso No. 1 at 7440 ft as a dry hole just west of the Ragusa field. This company has one rig and Gulf Italia two.

Jersey Standard has joined a local Sicilian company, Raffineria Siciliana Olii Minerali, in the formation of a new company, Augusta Ricerche Petrolifere, SFA, for the exploration for oil near Catania and Augusta. The new company has licenses covering 215,000 acres for 3 years. Jersey's associate in this venture, RASIOM, operates a 40,000 b/d refinery at Augusta, processing Middle East crude.

D'Arcy Petroleum has resumed its search for oil in the district between Vittoria, Acate and Caltagirone. No wells have been drilled in this region, but geological structure of the area is similar to that of the land around Ragusa.

SOMALIA (Italian Somaliland)

Sinclair Somal Corporation (Sinclair ½, Conoco ⅙, Amerada ⅙ and Ohio ⅙) conducted seismic operations during 1955 with two crews in the central part of the East African concession and conducted additional surface geological investigations in the northeastern part of the concession. Plans are to drill in 1956.

A subsidiary of ENI, Italian state-owned firm, has a concession in the north.

SOMALILAND (British)

Two exploration parties, one geological and one geophysical, are conducting surface investigations on the concessions acquired by Standard-Vacuum from the Moriqui Exploration Company in this territory south of Ethiopia.

One seismic party and 2 surface parties were at work for Conorada (Conoco-Somal) in 1955.

SOUTH AFRICA

R. C. 15,600 b/d

The Standard-Vacuum refinery at Durban increased its crude throughput rate to 18,000 b/d from a 15,600 bbl rate in 1955. The fuel products refinery added a polymerization plant in November 1954.

State-owned SASOL's oil-from-coal plant at Sasolburg did not get fully on stream in 1955.

SPAIN

R. C. 74,000 b/d

CIEPSA has proceeded with geophysical work and drilling. Gas was encountered in the Zuniga well near the French frontier, in a geological formation similar to that found in the Lacq wells in France. The importance of this finding has not been determined.

Empresa Nacional Adaro has reported gas shows at Ecija where the company has been aided by Italian technicians who have experience with gas in the Po Valley. Valdebro has drilled two wells without success. CAMPSA, after a period of inactivity, has resumed drilling work, whereas a few other companies have continued exploration activities. Three rigs operate in Spain.

Total effective refining capacity is now about 74,000 b/d. The Teneriffe, Canary Islands, refinery handles about 30,000 b/d and the Cartagena has 44,000 b/d. Since February 1955, the 5000 b/d platformer and 500 b/d Udex Unit have been operating in the CEPSA Teneriffe refinery.

The REPESA Cartagena refinery now has complete lubricating oils facilities under normal operation with a capacity of some 600 b/d.

Both the Cartagena and Teneriffe refineries are being enlarged. A new distillation plant and platformer are scheduled to be put into service in 1957 at Cartagena. In the Teneriffe plant a new distillation unit is expected to go on stream in 1956.

Spain had the amazing consumption increase of 38 per cent in oil products, mostly black products, in 1954 (see "Petroleum Achievements in Spain," The Petroleum Engineer, June 1955 Page A-51) and probably averaged 63,000 b/d in 1955.

SUMATRA (Indonesia)

Prod. 204,000 b/d **R. C. 160,000 b/d**

Standard-Vacuum's $20 million modernization program at Sungei Gerong refinery near Palembang is part of the company's $80 million four-year investment program in Indonesia. The refinery projects include the addition of a fluid catalytic cracking plant, a polymerization plant and the re-vamping of existing equipment. The crude throughput capacity will remain at the 65,000 b/d level. These improvements are scheduled for completion by the end of 1957, when a 90-mile crude pipe line connecting the Lirik Central Sumatra producing field to deep-water transportation facilities also will be ready.

Shell's plant at Paladju has a 95,000 b/d capacity. The company's refinery at Brandon, North Sumatra has never been reactivated since World War II and its oil fields here are operated by the government for local use.

Caltex is developing its Minas field in Central Sumatra.

SWEDEN

R. C. 41,00 b/d

Early in 1955 the Swedish government began drilling operations in the south.

The Koppartrans Olje AB refinery at Goteborg is being expanded. Swedish consumption rose about 20 per cent each of the last two years to some 160,000 b/d.

SWITZERLAND

R. C. 1800 b/d

Some exploration work has been done in south Tessin and near Geneva.

Virtually all the 40,000 b/d oil products demand must be imported. Increase of consumption runs around 15 per cent a year. There is some hope of oil deposits in the Molasse Basin but exploration in each canton must be done under local contracts.

Molasse Erdol-Forderungs AG (MOFAG) was organized in March 1955 at Bern by Jack H. Heathman, Wichita, Kansas and A. A. Seeligson Jr., San Antonio, Texas (Heathman-Seeligson Drilling Company) and obtained license to explore in Switzerland and Italy. Extensive geological and geophysical surveys have been made by MOFAG.

SYRIA

Syria and the Iraq Petroleum Company have come to an agreement on payments from pipe line transit of Iraqi oil through Syria. Estimated payment in 1956 will be more than $18 million. This does not include Tapline revenues for transmission of Saudi Arabian oil across Syria.

The government plans a refinery near Homs for Iraqi crude. Russia has offered to build it cheaply. Royal Dutch-Shell was also said to be negotiating for the contract of constructing and operating the proposed plant. (Last report was that Russia had the contract.)

TANGANYIKA

Two geological and two geophysical parties are at work in Tanganyika, East Africa on a concession held by D'Arcy and Shell. A stratigraphic test was drilling on Mafia Island, offshore, at the end of the year.

Two other rigs are in operation.

THAILAND (Siam)

A report has not been made on the aerial oil survey completed in 1954 over the Bangkok plain. This was made for the government.

TRIESTE

R. C. 24,600 b/d

Aquila's refinery has an 18,000 b/d capacity and Esso's plant has 6600 b/d crude capacity.

TRINIDAD

Prod. 68,350 b/d **R. C. 120,000 b/d**

The total production for Trinidad was 24,946,000 bbl. This established a production record for the third successive year, with a 5½% increase over 1954. Details are as follows:

	1954	*1955*
Total oil production (bbl)	23,627,000	24,946,000
Average number of rigs	26	27
Wells completed	201	230
Producers (oil or gas)	188	198
Footage drilled (ft)	911,242	993,409

The distribution of leases changed little during the year, and exploration activity continued on the same scale as previously, with 10 wildcats completed and 2 drilling. Only one important discovery was made, with the completion of Trinidad Northern Areas' first marine well, Soldado 1, six miles north of the Cedros peninsula.

In two wildcats drilled in North Central Trinidad discovered gas, the first in the Northern Basin. Dominion Oil Ltd. (Standard of California) continued its exploratory drilling program in the Northern Basin. Gas in commercial quantities was discovered in the Mahaica area.

Interesting operational developments include the introduction of a drilling barge by one company to develop its offshore field and U.S. drilling contractors have been brought into the island for land drilling. No major constructional activity took place during the year.

Largest refinery is Trinidad Leasehold's 85,000 b/d plant at Pointe-a-Pierre. Shell has a 30,000 b/d refinery at Point Fortin and Texas Co. bought a 5000 b/d plant at Brighton. Runs are close to total capacity of 120,000 b/d.

TRUCIAL COAST

A further survey of the character of the seabed, also shallow drilling, is to be undertaken about 50 miles off Abu Dhabi, Persian Gulf, in the offshore concession held jointly by BP and Compagnie Francaise des Petroles.

Gezira No. 1 wel was spudded-in by Petroleum Development (Trucial Coast) Ltd. (Iraq Petroleum) on January 20, 1955 and 12,500 ft were drilled during the year.

DIG 17¾ FEET DEEP with Koehring ½-yard hoe

There are several reasons why you should look into this heavy-duty ½-yard hoe. For one thing, you get exceptionally wide work range on trenches, slush pits, footings and other below-grade excavations. It digs 17¾ feet below crawlers. Long reach puts spoil bank well beyond edge of cut — and gives up to 8¾ foot clearance height (at beginning of dump) to load trucks. ½-yard dipper makes a wide cut — 31 inches over side-cutters. During dig-and-swing cycle, close-coupled dipper pulls up tight to boom, avoids spillage as boom swings out of the cut.

Behind the Koehring 205's powerful cable crowd, fast line and swing speeds is plenty of *reserve* strength for heaviest digging assignments. Big, 20-inch main-drum clutches are among the largest used in the ½-yard class. Antifriction power-flow on dig, hoist, swing and travel assures smooth, dependable operation under maximum loads. Automatic traction brakes simplify operation — safely lock and hold the 205 when working or parked. Operators like the 205's ease of operation. You'll like the *extra work capacity* you get with every attachment. For example —

This big-capacity 205 readily converts from hoe to ½-yard shovel, handles ½ to ¾-yard clamshell or dragline buckets on a wide work radius — has 10-ton capacity as a crawler-mounted crane. It's available with all standard attachments on 32½ m.p.h. truck mounting. Koehring 205 truck crane has 15-ton capacity. Better look into this heavy-duty 205 soon. Ask your Koehring distributor to demonstrate what it will do for you. See him, or write us. (Four larger sizes of excavators and cranes also available in the Koehring line.)

KOEHRING COMPANY
Milwaukee 16, Wisconsin
(*Subsidiaries:* Kwik-Mix • Parsons • Johnson)

K561

TUNISIA

Two companies have carried on exploration work in Tunisia in 1955. The SEREPT (French and Tunisian interests) has operated during the year 3 rigs, 2 in Tunisia and the 3rd in Algeria for SN REPAL. At the end of September, 1955, SEREPT had put into activity a 4th rig. With one rig in the Djebel Bargon and another in the Djebel Kebir, near the Algerian frontier, SEREPT has completed exploration of the north and the south of Tunisia. With the exception of gas in the Cap Bon no reserves have been found.

Stratigraphic drilling has been carried out in the extreme south of Tunisia, geologic and geophysic work (2 gravity meter and 2 seismic crews) and core-drilling have been carried on all year.

CPDT (Shell and SEREPT) have continued exploration of the Sahel at first with 3, then with 2 rigs.

TURKEY

Prod. 2730 b/d R. C. 6250 b/d

Turkey's Petroleum Law of March 1954 prepared with the help of the late Max Ball was amended during May 1955 to clarify certain ambiguities with the object of making it more attractive. Altogether, 12 companies filed applications for 187 licenses, most of them overlapping one another. The almost impossible task of clearing the conflicts was accomplished by the end of the year. The 12 companies mentioned above are: The American Overseas Petroleum (Caltex), Bolsa Chica, C. Deilmann, D. D. Feldman Oil & Gas, Esso Standard of Turkey, Gilliland Oil Corp., Husky Oil Corp., Istanbul Natural Gas (Parsons), Royal Dutch-Shell, (Socony) Mobil Oil Turk S.A., Tide Water Associated, Turkiye Petrolleri A.O. Atlantic had filed in 1955 and was granted concessions early in 1956.

Production in Raman field, which was doubled in 1954, was tripled during 1955 reaching a figure over 1,000,000 bbl for the year. Five rigs are running. Producing wells now are more able to take care of the 6250-bbl catalytic cracking refinery built by Ralph M. Parsons. This refinery was placed on stream at the end of 1955.

USSR

Prod. 1,410,000 b/d? R. C. 1,400,000 b/d?

Outpaced by free world oil operations at present, the USSR sets up an ambitious Five-Year Plan for the 6th time in which oil and gas plays a prominent part.

Crude oil production is set at 135 million tons in 1960, or an increase of 91 per cent over the 70.7 million tons said to be produced in 1955.

Natural gas production for 1960 is planned for 40 billion cu meters, 288 per cent greater than the 10.3 billion announced for 1955.

Refining capacity is to be increased by 900,000 b/d.

Construction of all types of pipe lines will total 5600 miles.

The difficulties Russia encounters in reaching its goals are many (See "Deep Wells in Russia Find New Oil," February 1956, Pg. B-27 and "USSR Pushes Natural Gas Industry," December 1955, Pg. E-3, *The Petroleum Engineer*) but goals of the last Five-Year Plan are said to have been fulfilled. News and radio reports avoid specific items but there are a few. A 750 mile 28-in. gas line is being laid from Stavoropol to Moscow. The first oil refinery in Siberia was put on stream at Oinsk. An agreement has been made whereby the turbodrill, used to depths of up to 13,000 ft, will be manufactured in the U.S. by Dresser Industries. Production in the second Baku, in the Ural-Volga Basin, has almost quadrupled since 1950.

UNITED KINGDOM

Prod. 1060 b/d R. C. 577,100 b/d

D'Arcy Exploration Company (BP) discovered in May, 1955 a new oilfield at Egmanton, Nottinghamshire, 6 miles from the established oilfield at Eakring. At Plungar, also in Nottinghamshire, where oil was first discovered in 1953, development of the field continues. At Nocton in Lincolnshire, where 5 wells were completed during the war, further drilling is now in progress. Total rigs in operation are 6. BP's production of crude oil in the United Kingdom in 1955 amounted to 53,000 tons.

The search for natural gas which the D'Arcy Co. is undertaking on behalf of the Gas Council continues in many parts of the country, including Yorkshire, the Cheshire Basin, Northumberland and Durham.

At BP's Kent refinery on the Isle of Grain, Kent, a new expansion scheme is planned which will raise capacity from the present 4½ to 7 million tons a year.

An agreement has been signed with the South Eastern Gas Board for the erection of plant at the Kent refinery for the production of town gas wholly from oil products. Kent refinery is also to install plant for the production of about 130,000 tons of aviation gasoline a year.

Crude capacity of two plants of Shell Refining and Starhaven Refineries at Shell Haven (700,000 b/d and Stanlow (100,000 b/d) has been expanded.

Vacuum's (Socony) new plant at Coryton is running above its 22,000 capacity.

Esso's Fawley plant (150,000 b/d) is adding a 27,000 b/d vacuum still and a 15,000 b/d hydroformer.

UNITED STATES

Prod. 6,778,000 b/d R. C. 8,42,000 b/d

In 1955 U. S. operators drilled 56,400 wells of which 12,100 were wildcats. Production of crude oil was 6,778,000 b/d not including LPG, which average 721,000 b/d.

Refinery runs average about one million barrels a day under capacity 7,474,000 b/d.

Demand, including exports ran some 8,726,000 b/d. Imports averaged 1,246,000 b/d.

URUGUAY

R. C. 27,000 b/d

State-owned ANCAP employed a U. S. contractor last year and 4 wells were drilled at San Jacinto, 60 miles east of Montevideo, without obtaining commercial production. Next site for the one rig has been selected 30 miles north of Montevideo.

ANCAP has the only refinery which is at Montevideo.

VENEZUELA

Prod. 2,155,000 b/d R. C. 540,000 b/d

There was considerable talk in 1955 about the government of Venezuela throwing open new lands for oil and gas concessions but nothing was done until January 12, 1956. This move has been made before without applications being acted upon.

At present 16 companies (14 U. S. companies) are operating in the country, which has production second only to the U. S. Less than half as many rigs — 112 — are in operation as there are in Canada (250).

Creole (Standard of New Jersey) is the largest producer, with about half the output. Creole is spending $180 million in 1956 to expand its facilities. It will expand Amuay refinery from 140,000 b/d to 240,000 b/d and increase storage.

Shell Oil, which first found oil in Venezuela, produces some 573,000 b/d. It is spending $40 million on its Cardon refinery to raise capacity from 175,000 to 255,000 b/d. The company is laying a 20-in. 177-mile gas pipe line from La Paz field to Carden. Gas will be used as fuel at the plant.

Mene Grande Oil, which had 314,000 b/d production in 1955, has 2 geophysical and 2 geological parties in the field. An average 26 rigs drilled 260 wells, of which 229 were producers.

Venezuelan Atlantic Refining, Atlantic Refining subsidiary, during the 12 months' period ending November 30, 1955, completed a total of 54½ net wells of which 26½ were oil and one gas. Crude oil production averaged 12,554 b/d, a 5% decrease.

Venezuelan Atlantic Transmission, which distributes natural gas from fields in Guarico to industrial and commercial consumers in Caracas and other nearby points, had reached 46,000 MCF/d during November, an increase of 31½%.

Continental Oil during the year was represented in various groups of companies having seismograph crews in the Barinas Basin and in offshore seismic work in the Gulf of Paria.

Richmond Exploration (Standard of California) conducted extensive development drilling in the Boscon field of Venezuela. Productive capacity at the end of the year approximated 60,000 b/d. Construction of a 10,000 b/d asphalt refinery at Bajo Grande was begun, with completion scheduled for July 1, 1956.

Socony Mobil production in eastern Venezuela is running about 90,000 b/d. In Western Venezuela the company is obtaining rights-of-way for a pipe line and acquired land near Puerto Cabello for a crude terminal and refinery site.

YEMEN

The Yemen Development Corporation, Washington, D. C., and Dallas, Texas, negotiated a concession on oil, gas and minerals on 40,000 sq miles with the Kingdom of Yemen which is on the south tip of the Arabian peninsula. The concession is for a term of 30 years. There is an obligation to carry out exploration work, and if something of economic value is found, to exploit it. Oil and Gas Property Management, Dallas, Texas, is one of the principal owners of the Yemen Development Corporation.

YUGOSLAVIA

Prod. 4300 b/d R. C. 17,000 b/d

Compared with 1954, the figures for 1955 show some progress in Yugoslavia:

Production of crude: 1954, 1,554,650 bbl; 1955, 1,848,900 bbl.

Production of natural gas: 1954, 3,183,000 MCF; 1955, 1,946,000 MCF.

Processed crude: 4,776,080 bbl; 1955, 5,350,440 bbl.

Imported crude oil: 1954, 449,276 metric tons; 1955, 483,024 metric tons.

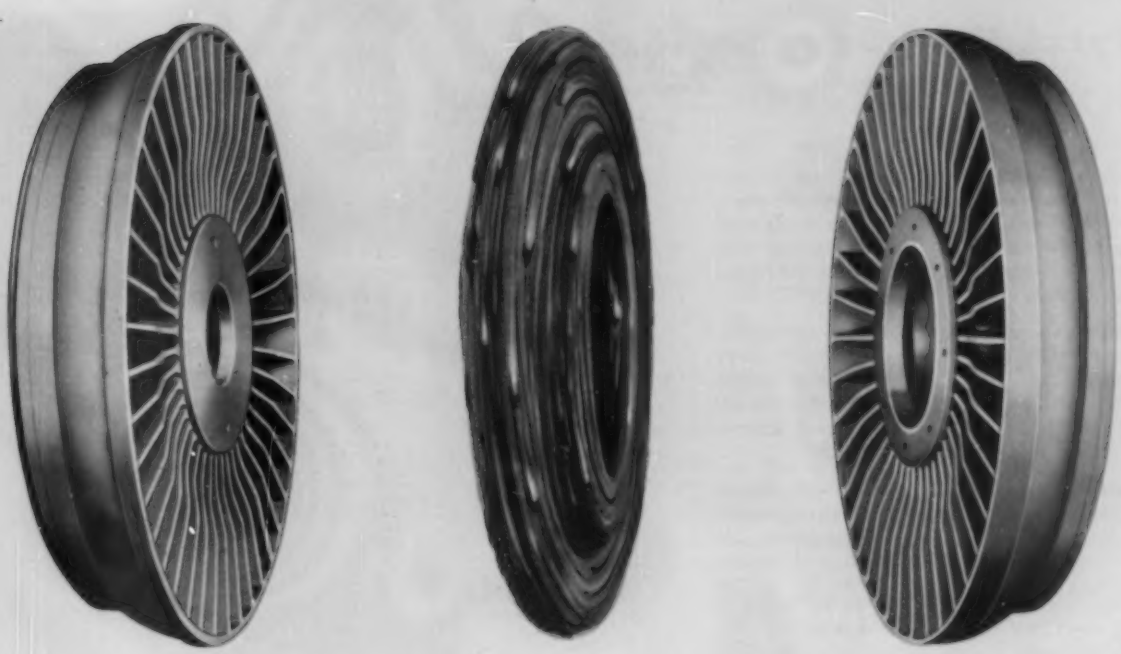
In 1955 the deepest well was drilled at Gabreje P. R. Slovenia (9974 ft).

Two pipe lines for natural gas have been laid. The first, about 19 miles long, connected the natural gas deposit Velika Greda Aut. Dis. Voyvodina P.R. Serbia with the town of Vrsac; the second connects the natural gas and oil deposits Klostar P.R. Croatia with the town of Zagreb, some 26 miles.

Wildcats near Boka A.D. Volvodina P.R. Serbia discovered natural gas and oil at a depth of 4104 ft. Wildcats near Filovci P.R. Slovenia also found gas.

ZANZIBAR

D'Arcy-Shell has concession on this island off Tangayika in the Indian Ocean.



AMERICAN BLOWER
GÝROL® FLUID DRIVE

improves

Simplifies control—Driving machinery through a vortex of oil, American Blower Gýrol Fluid Drive offers unparalleled control advantages. By merely regulating the amount of oil in the vortex with a simple speed-control rod, stepless speed and torque adjustments are possible within the power range. This stepless, direct speed control—plus the cushioning effect of the fluid flow—matches a motor or engine to the machinery; lets operators control acceleration smoothly and gradually with no-load starting; and in many cases makes across-the-line starting truly practical.

Extends equipment life—Since American Blower Gýrol Fluid Drive eliminates rigid mechanical connections, and transmits torque at a 1:1 ratio—its oil vortex protects both the prime mover and the driven machinery. As a liquid shearpin, Gýrol Fluid Drive prevents the transmission of sudden shock loads, torsions, and vibrations. It reduces wear and shutdowns. Gýrol Fluid Drive adds further protection and service life to equipment through its unique ability to stall under excessive overload conditions.

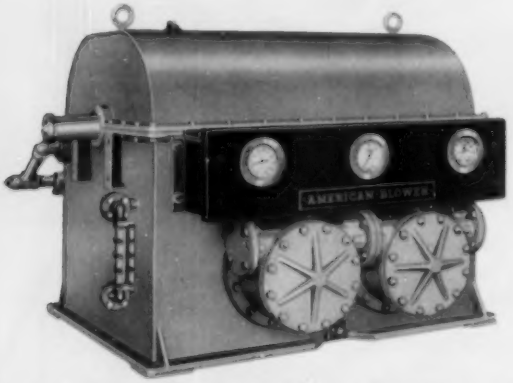
American Blower Gýrol Fluid Drive can be used with most sizes and types of electrical motors and internal-combustion engines . . . bringing smooth, adjustable-speed benefits to many applications.

Gýrol Fluid Drive in DRILLING

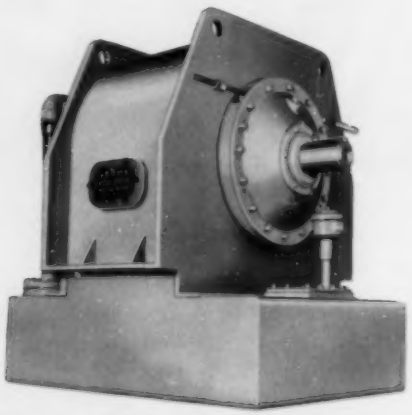
1. **Draw works** – Gýrol Fluid Drive assures smooth starts against full connected hoist load, and maintains optimum hoisting rate, minimizing the danger of stalling the engine. Hoist operator easily controls acceleration.
2. **Rotary** – In addition to supplying adjustable, stable speed and power to the rotary table, Gýrol Fluid Drive allows speeds below minimum engine rpm without stalling engine. Protects against jams. Adjusts torque to suit drilling resistance.
3. **Slush pump** – Smooth power from engine to pump flows with maximum efficiency (94% to 96%). As engine approaches full load with increased pressure and depth, Gýrol Fluid Drive can slow the pump while engine operates in most efficient range. Allows pump to hold pressure with output shaft stalled or slightly turning.
4. **Compounding** – Gýrol Fluid Drives can be used effectively on any compound design without need of overloading one engine. A Gýrol unit can remain idle while other engines carry the load, and be quickly and easily applied whenever desirable without any reconnecting operations.

AMERICAN BLOWER Gýrol Fluid Drives offer you improved control, shockless, adjustable speed and less equipment wear

Because of its unusual flexibility and efficiency, American Blower Gýrol Fluid Drive improves numerous operations in the oil industry. Not only does its stepless, shockless, adjustable speed pay off in better control and lower maintenance costs, but also power savings are often realized through lower horsepower requirements. In addition, Gýrol Fluid Drive comes in a wide range of sizes, speeds, and horsepower ratings; is adaptable to various arrangements; and offers remote, manual, or automatic speed control.



Class 4 and 6, Type VS Gýrol Fluid Drives, 100 hp to 12,000 hp, speeds to 3600 rpm



Class 2F, Type VS Gýrol Fluid Drive, 280 hp to 820 hp, speeds to 1200 rpm

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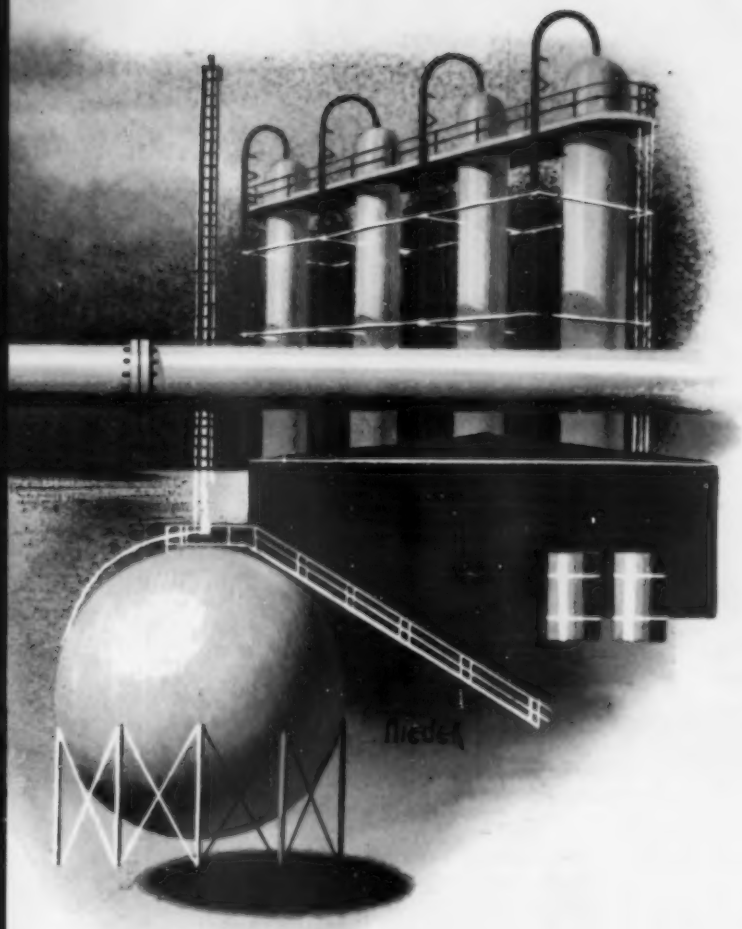
Gýrol Fluid Drive in PIPELINE COMPRESSOR STATIONS



1. **Jacket water coolers** – Using Gýrol Drives, fan speed can vary automatically, from 0 rpm to full speed, in relation to engine operation and cooling requirements. Also Gýrol units conserve power, protect jack shafts.

2. **Pumps** – To gain wide-range flow control of oil with various densities, it has been conventional to use several small engines with discharge throttle valves. Now, the adjustable-speed advantage of a high-horsepower Gýrol unit eliminates the complexity and extra cost of this type system. Gýrol Fluid Drive automatically controls pump speed . . . provides the desired flow capacity, relative to the types and amounts of product batches in the pipeline.

3. **By-product reclamation** – The operations that separate so-called "impurities" from gas are also benefiting with the shock-absorbing, adjustable-speed features of American Blower Gýrol Fluid Drive. On extruding machines handling by-product plastic, for example, the smooth Gýrol unit permits across-the-line, no-load starting . . . and insures proper extrusion under varying density, temperature, and load conditions.

Gýrol Fluid Drive in REFINERIES

1. **Catalytic Reforming Processes**—Accurate control of the flow of gases and fluids is the key to the successful operation of a catalytic reforming plant. Because its speed is adjustable, American Blower Gýrol Fluid Drive can vary the flow rates of compressors and pumps of all sizes and types – as needed. Simplifies starting equipment. Provides no-load starting.

2. **Centrifugal and positive displacement pumps** – Requiring adjustable flow, the modern refinery depends on a network of centrifugal and positive displacement pumps with from small to large horsepower requirements. Gýrol Fluid Drive's wide horsepower range meets these needs – and more important – provides varying flow without the use of throttling valves. Thus, the sticking of these valves resulting from gummy petroleum conditions is also eliminated . . . along with high maintenance and unnecessary shutdown.

3. **Catalyst rejuvenators**—The rejuvenating process using furfural has been a boon to extending the life of precious catalysts, such as platinum. And a big help to this and other refinery reforming processes that require adjustable speed and high-inertia starts is Gýrol Fluid Drive. The smooth, shockless power transmission it brings satisfies rigid drive requirements; lets you engage the load with engine at full rpm; and permits across-the-line starting of normal-torque, general-purpose motors.

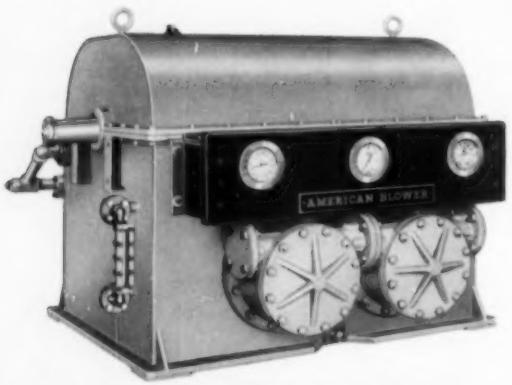
Class 2, Type VS Gýrol Fluid Drive, 1 hp to 800 hp, speeds to 3600 rpm

Gýrol Fluid Drive in DRILLING

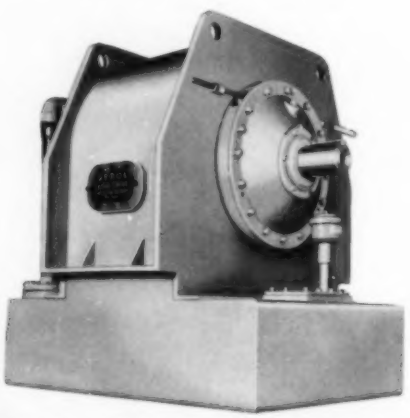
1. **Draw works** – Gýrol Fluid Drive assures smooth starts against full connected hoist load, and maintains optimum hoisting rate, minimizing the danger of stalling the engine. Hoist operator easily controls acceleration.
2. **Rotary** – In addition to supplying adjustable, stable speed and power to the rotary table, Gýrol Fluid Drive allows speeds below minimum engine rpm without stalling engine. Protects against jams. Adjusts torque to suit drilling resistance.
3. **Slush pump** – Smooth power from engine to pump flows with maximum efficiency (94% to 96%). As engine approaches full load with increased pressure and depth, Gýrol Fluid Drive can slow the pump while engine operates in most efficient range. Allows pump to hold pressure with output shaft stalled or slightly turning.
4. **Compounding** – Gýrol Fluid Drives can be used effectively on any compound design without need of overloading one engine. A Gýrol unit can remain idle while other engines carry the load, and be quickly and easily applied whenever desirable without any reconnecting operations.

AMERICAN BLOWER Gýrol Fluid Drives offer you improved control, shockless, adjustable speed and less equipment wear

Because of its unusual flexibility and efficiency, American Blower Gýrol Fluid Drive improves numerous operations in the oil industry. Not only does its stepless, shockless, adjustable speed pay off in better control and lower maintenance costs, but also power savings are often realized through lower horsepower requirements. In addition, Gýrol Fluid Drive comes in a wide range of sizes, speeds, and horsepower ratings; is adaptable to various arrangements; and offers remote, manual, or automatic speed control.



Class 4 and 6, Type VS Gýrol Fluid Drives, 100 hp to 12,000 hp, speeds to 3600 rpm



Class 2F, Type VS Gýrol Fluid Drive, 280 hp to 820 hp, speeds to 1200 rpm

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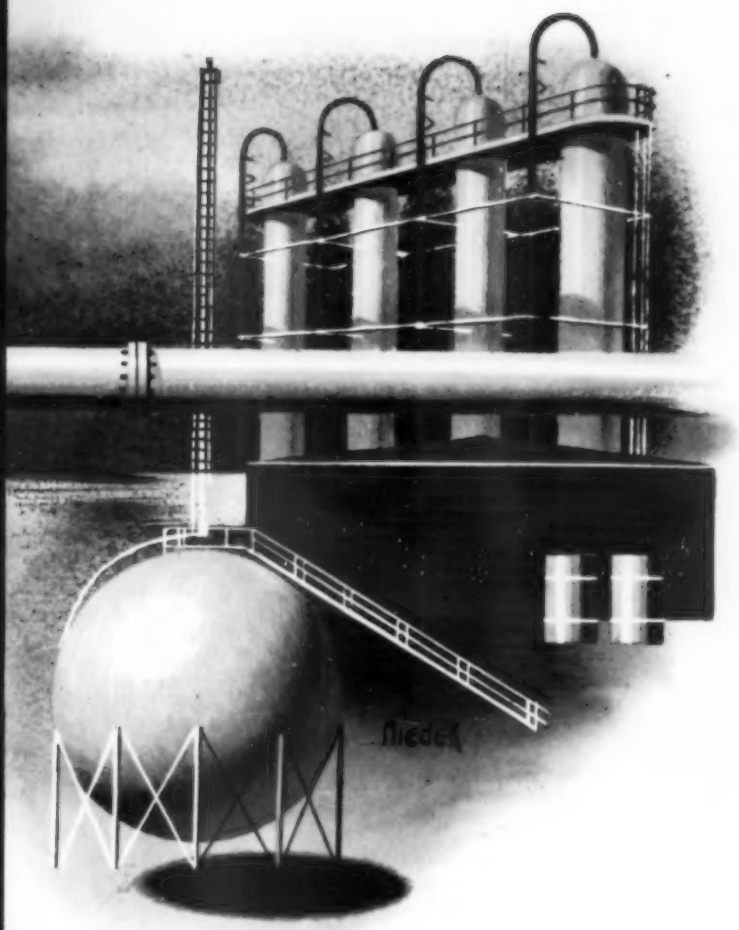
Gýrol Fluid Drive in PIPELINE COMPRESSOR STATIONS



1. **Jacket water coolers** – Using Gýrol Drives, fan speed can vary automatically, from 0 rpm to full speed, in relation to engine operation and cooling requirements. Also Gýrol units conserve power, protect jack shafts.

2. **Pumps** – To gain wide-range flow control of oil with various densities, it has been conventional to use several small engines with discharge throttle valves. Now, the adjustable-speed advantage of a high-horsepower Gýrol unit eliminates the complexity and extra cost of this type system. Gýrol Fluid Drive automatically controls pump speed . . . provides the desired flow capacity, relative to the types and amounts of product batches in the pipeline.

3. **By-product reclamation** – The operations that separate so-called "impurities" from gas are also benefiting with the shock-absorbing, adjustable-speed features of American Blower Gýrol Fluid Drive. On extruding machines handling by-product plastic, for example, the smooth Gýrol unit permits across-the-line, no-load starting . . . and insures proper extrusion under varying density, temperature, and load conditions.

Gýrol Fluid Drive in REFINERIES

1. **Catalytic Reforming Processes**—Accurate control of the flow of gases and fluids is the key to the successful operation of a catalytic reforming plant. Because its speed is adjustable, American Blower Gýrol Fluid Drive can vary the flow rates of compressors and pumps of all sizes and types – as needed. Simplifies starting equipment. Provides no-load starting.

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Class 2, Type VS Gýrol Fluid Drive, 1 hp to 800 hp, speeds to 3600 rpm

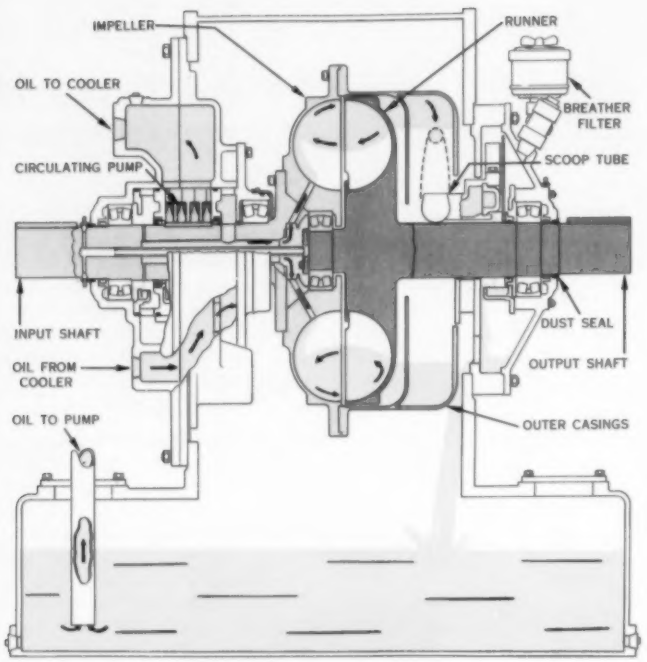
OTHER GÝROL FLUID DRIVE APPLICATIONS IN THE PETROLEUM INDUSTRY

Mud reclamation – Supplying mud to lubricate the bit and remove drillings is one of the biggest expenses in drilling a well. Thanks to Gýrol Fluid Drive and a decanting-type centrifuge, this precious mud can now be reclaimed and used again. The centrifuge requires high starting torque, and adjustable speed from 1800 to 3200 rpm. Gýrol Fluid Drive provides these features, as well as eliminates the need of complicated, electrical starting equipment.

From variable speed to constant speed – When large pipeline pumping stations require alternating current for station auxiliaries, it is sometimes desirable to drive a generator from the main station engines. But, since various speeds are required of these engines for adjusting product flow through the pipelines, a problem arises when they must also drive a generator at constant speed . . . and constant speed is needed for good cycle and voltage regulation. The answer? Gýrol Fluid Drive! By interposing it between the engine take-off and the generator, the Gýrol unit transmits constant speed, as engine rpm fluctuates over a wide range. Even under sudden load demands on the generator, close cycle control is maintained.

Saving gears – Large gas or diesel engines in pipeline stations usually require high-speed scavengers and/or superchargers which are driven directly from the main crankshaft of the engine. Torsional vibrations generated by the crankshaft can cause early and complete failure of the step-up gears. With Gýrol Fluid Drive as a coupler to the scavenger or compressor, these torsional vibrations are isolated, and consequent gear failure is eliminated.

A CLOSER LOOK TELLS WHY GÝROL FLUID DRIVE IS THE IDEAL POWER TRANSMITTER FOR YOU



Cutaway of Type VS, Class 2F, typifies Gýrol Fluid Drive operation.

The secret of Gýrol Fluid Drive's simplified control and smooth, infinitely adjustable speed transmission rests with an uncomplicated, foolproof scoop tube. One external push-pull rod – which may be operated remotely, manually, or automatically – positions the scoop tube to regulate the amount of oil in the vortex. Extend or retract the scoop tube, and you proportionately alter output speed.

If an overload condition arises, the oil vortex allows the input impeller to slip – thus relieving stresses and strains on equipment. The resulting heat generated in the oil is dissipated by an external oil cooler.

A pump continuously circulates the oil from the working vortex through the scoop tube to a reservoir in the casing. Leaving the reservoir, the oil goes to the cooler, and returns to the working circuit through the center of the input shaft. Except during periods of speed change, the scoop tube handles a constant amount of oil.

Adjustable-speed Gýrol Fluid Drives come as complete, self-contained units; are designed, manufactured, and rigidly inspected to meet the long service requirements of the oil industry.

For further information, and application assistance – call your nearby American Blower representative, or write us direct.

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Bulletin 9919

40 BELOW

A D6 BUILDS A ROAD, PREPARES A SITE

AND 4 FEET OF SNOW

R. N. Robinson, Hayden, Colo., prepared a site for the Texas Company 12 miles west of Steamboat Springs. Elevation was 8000 feet, temperatures dipped to 40 below and four feet of snow were on the ground. He picked a CAT* D6 Tractor to build an access road, dig pits and excavate for foundation footings.

"I know the record of Cat-built equipment in cold, mountain country," he explained. "My Cat Diesel Tractors always have been reliable. They run longer and cost less than any other tractor."

The D6, like all Caterpillar-built equipment, is designed for hard and heavy service in oil patches around the world—whether in arctic or tropical climates. The great new oil clutch is an example. Not only does it add dependability, but it reduces service and maintenance costs. Clutch adjustments are rarely needed. Disc replacements are required no more frequently than engine overhauls.

You'll never run out of jobs for these work horses. They clear brush, level sites, build roads, dig and fill pits, dig gathering line trenches, dike storage tank areas and level finished well sites. From site preparation to cleaning up, they are your most versatile machines.

And no matter what the footing, you'll find these machines have the sure traction and power to do all these jobs quickly and inexpensively.

Your nearby Caterpillar Dealer has the exact units you require. And he'll demonstrate any of his profit-making equipment on *your* job . . . at *your* convenience. See him soon.

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YOUR DEALER
WILL DEMONSTRATE**

Refinery units at British-American's Edmonton Refinery.

CANADIAN OPERATIONS Hit a Hard Pace

Activity is up all along the line . . . only transmission line construction slowed in 1955, and it may make 1956 boom . . . Billion-dollar Trans-Canada line must put up or shut up . . . Canadian oil stands to gain in the "Continental Concept" of exchange with U. S. to obtain self-sufficiency.

H. G. Cochrane

WESTERN Canada's oil production made a spectacular comeback during the latter half of 1955. Output for the year rose to almost 129,000,000 bbl of crude and other liquid products, a gain of 35 per cent over 1954's output of 95,700,000 bbl compared with an 18 per cent gain in 1954 over the previous year.

Eight months ago, oil executives were "whistling in the dark." Imperial's President J. R. White told a New York group that the growth of production and development in Western Canada was "tapering off from the post war skyrocket phase to a more rational rate of progress." A wet spring had curtailed drilling in Alberta and Manitoba. Seismic crews were down by a third, markets for Western grain were tightening, and a slump in sales for the year was predicted compared with 1954.

Though the return per barrel was moderately lower in 1955 than in the previous year, largely on account of price adjustments in some Alberta fields, the average daily production for 1955 gained 91,000 bbl per day over the 1954 average. Canadian markets between Toronto and Vancouver absorbed a little over a half of this gain, while Midwest-lakehead areas and Pacific Coast states took the balance. Canadian markets consumed 85½ per cent of Western Canada's output while United States markets absorbed 14½ per cent. This division compared with 97 per cent Canadian and 3 per cent U.S. consumption in 1954.

EXCLUSIVE

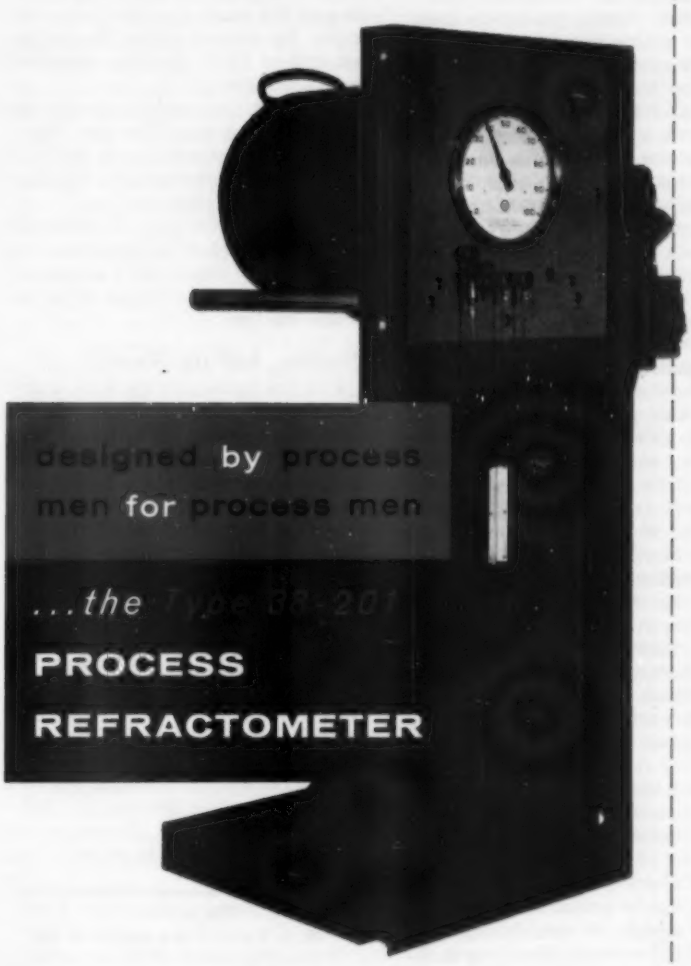
Reserves Up 35 Per Cent

Reserves of crude in the three prairie provinces and Northwest Territories stood at year's end at 3¼ billion barrels, compared with 2.4 billion a year ago, due to rate of exploration and development never before attained. After subtracting the year's production of some 129,000,000 bbl, the net increase was some 537,000,000 bbl. Reserves by provinces now stand as follows: Alberta — 2.9 billion, up 450,000,000 from 1954; Saskatchewan — 300,000,000, up 75,000,000 net during the year; Manitoba—45,000,000, up 12,000,000 from 1954; and the Territories — 25,000,000, the same as a year ago.

For the year a total of 158 discoveries were recorded, 90 of which were oil, 58 of dry gas and 10 of wet gas. New discoveries included that at Clear

Here's a process-control instrument built on experience . . . CEC's 38-201 Process Refractometer. This process analyzer was proved *around the clock* for several years in actual process operations at the various refineries of its original designer, the Phillips Petroleum Company. Now, as a "Consolidated-Phillips" instrument, it's backed by Consolidated Electrodynamics' nationwide service organization . . . assurance of interruption-free service for years to come. And CEC's experienced Application Service is available to discuss applications, diagnose problems or aid in the development of new automatic analysis and control systems.

Here's above all a *practical* process monitor and controller, which can materially lower your costs and raise both throughput and quality. For the complete story of the 38-201 Process Refractometer, write today for Bulletin CEC-1839 X21.



What it measures . . .

. . . the 38-201 measures the difference in refractive index between a liquid standard and a flowing liquid sample obtained *directly from a process line*. Refractive index is related to density and thus is able to provide a direct indication of relative composition changes in binary mixtures. When the process stream is complex, a binary mixture is approximated when all but one or two key compounds remain reasonably constant.

Its features . . .

RUGGED CONSTRUCTION—explosion-proof design permits use anywhere, even out-of-doors.

STABLE, DRIFT-FREE OPERATION—the differential-principle design provides freedom from ambient temperature changes. Sample temperature, pressure and flow are closely controlled and stabilized.

HIGH SENSITIVITY—maximum full-scale sensitivity is 0.0012 Refractive Index Units, minimum is 0.24. Unit observes both plus and minus deviations of the flowing sample.

SIMPLICITY—contains no controls requiring routine adjustment; once unit has been placed in operation, the operator makes only an occasional inspection.

FREEDOM FROM MAINTENANCE—basic design simplicity keeps unit operating without attention for long periods. If repairs are required, all electronic and optical assemblies are easily reached, and can be replaced quickly with standardized spare units.

How you can use it . . .

FRACTIONATOR CONTROL—Process Refractometers are saving hundreds of dollars per day through maintenance of product composition at Phillips Petroleum Company.

AUTOMATIC CONTROL—readily achieved by making the Process Refractometer an element of a feedback loop. Deviations from the desired R.I. then automatically adjust process parameters to bring end product back to standard.

BLENDING CONTROL—by using a sample of correctly blended liquid as the standard, the Process Refractometer, through use of variation in the sample R.I. to actuate pneumatic controllers, automatically controls blending operations, cuts losses from faulty product.

The Consolidated-Phillips group also includes:

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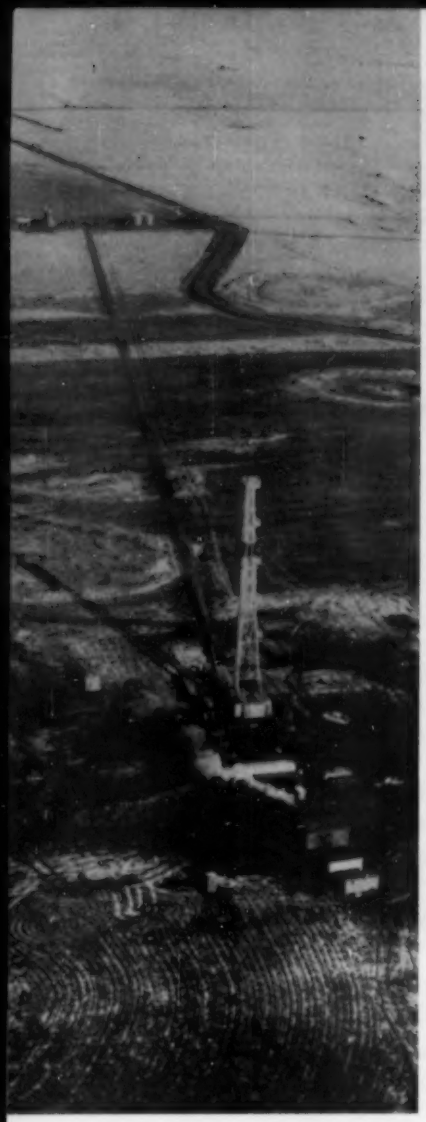


—Courtesy Shell

A view from the air of part of Shell's Midale field, showing an Arrow Drilling Company rig in its drilling location. In the background is the Enge lease battery.

Hills in the Peace River area, where a granite-wash light oil was struck early in the year with a 600-bbl per day flow; at Joffre, east of Red Deer, where a sizable Viking sand discovery was made; at Carrot Creek near Edmonton, a high-gravity D 1 Devonian find at 7700 ft depth; and at Gull Lake, where a Jurassic discovery of medium-light gravity oil was struck at 3900 ft.

Later in the year, additional discoveries were made at Westward Ho, 50 miles northwest of Calgary, of light-gravity oil with 1000-bbl per day potential; a Mississippian strike six miles south of it at Hermattan, with good indications of both oil and gas; and a Viking sand light crude success at Burbank, just north of Red Deer, which may turn out to be an extension to the Joffre field. A more recent find was at Goose Lake, 90 miles north of Edmonton, where light oil was found in the Basal Cretaceous, with a 50-ft pay zone. A land rush is currently underway in a previously neglected area in northeastern Alberta, following a granite-wash discovery by Union Oil of California in its Red Earth No. 12-17 wildcat. Applications are in for rights on some 9,000,000 acres.

Most Operations Increased

Potential. By year-end Western oil potential, or the maximum efficient potential rate of production from existing wells, had risen to nearly 700,000 bbl per day, 25 per cent greater than a year earlier. Actual production from the three prairie provinces amounted to 59 per cent of the potential. Daily production had peaked last July at a record 362,300 b/d.

Alberta's potential of some 625,000 bbl daily was being drawn on to the extent of some 50 per cent. Saskatchewan's potential at 50,000 bbl daily was being 75 per cent utilized, while Manitoba's potential at 18,500 bbl was being utilized to the extent of some 77 per cent. The small territories' potential was producing some 45 per cent of its possible output.

Completions. The 2879 wells completed for the year exceeded those of the previous year by 30 per cent. Of the total, 1900 were oil wells, 148 dry gas wells, 10 wet gas wells and 731 "dusters." Of these, 1500 were in Alberta, 885 in Saskatchewan, 362 in Manitoba, 38 in British Columbia, and 5 in the Northwest Territories.

Exploration has tended to move west towards the Alberta foothills of late. Saskatchewan also enjoyed a busy year of exploration with activity centered in the Success and Frobisher fields in the southern part of the province. Manitoba's activity was also increasing with reserves climbing to 40,000,000 barrels.

At work were 148 seismic crews and 8 gravity meter crews, compared with 118 total last spring. Of these, 108 were in Alberta, 23 in Saskatchewan,, 22 in British Columbia and 1 in Manitoba. Drilling rigs in operation at 251 represented a peak; 96 were drilling wildcats and 155 were on development, divided as follows: Alberta 173, Saskatchewan 49, Manitoba 18 and British Columbia 8. Footage drilled exceeded 6,000,000 ft in the first six months, will probably exceed 12,000,000 for the full year.

Exports. Much of the improvement for the latter part of the year was due to increased markets in Pacific States and in Northern Michigan. Throughput on the Transmountain pipe line stood at over 100,000 bbl per day at year end, more than half of which was going to the Anacortes Refinery.

This reflected the drop in the Canadian dollar to near par. Bay Petroleums in Northern Michigan, taking some 2500 b/d of Canadian Crude, is an opener to a potential market of 100,000 bbl daily in the northern part of the state. This area lies astride the Interprovincial pipe line, and the extra three to four cents saving due to a par dollar is making Canadian crude attractive.

Investment in the industry averaged some $44,000,000 per month for the year. As a measure of what this means to provincial treasuries, Alberta alone has taken in nearly $419,000,000 over the past 9½ years since the Leduc discovery for mineral rights. During the last half of 1955, the take amounted to $52,500,000.

Refinery expansion continued throughout the year. The new Sarnia wax plant was started late in 1955, as well as a $5,000,000 catalytic reformer for producing high-octane gas.

Imperial Oil's new $13,000,000 lubricating oil plant at Edmonton was opened in November and is capable of producing 41 different types of oil for prairie markets.

Pipeline Activity Slowed

Pipe line laying activity, down somewhat from previous years, should show a comeback during 1956. Interprovincial Pipeline has recently awarded contracts for looping on 119 miles of large-diameter pipe at $9,000,000. Besides this, pipe laying for the West Coast Transmissions' natural gas pipe line from the Peace River to Vancouver will be well under way during the coming season.

Self Sufficiency by Exchange

Plans are also now well advanced for extending the 1750-mile Interprovincial Oil pipe line a further 160 miles from Sarnia to Port Credit on the western outskirts of Toronto. The cost will be somewhere between $10,000,000 and $13,500,000, depending on pipe diameter and route chosen. Con-

The Author

H. G. Cochrane is a member of the Engineering Institute of Canada. After spending his early years on irrigation development in Alberta and Saskatchewan, he went east to build a number of large hydro-electric power plants in Quebec and Manitoba. He became interested in oil development in the late thirties while making preliminary studies and estimates of oil pipe lines to Lakehead and the Pacific Coast.

During World War II he conducted economic studies on scarce materials and services for the Canadian Government. He is presently with Power Corporation of Canada Limited at Montreal.

struction is expected to get under way in 1957. This will ultimately add an assured minimum of 30,000 bbl daily to Provincial's throughput, with two and possibly three new refineries to be built in the Toronto area.

For 1956, the industry foresees a 21 per cent increase in production to 157,000,000 bbl, or an average rate of 429,000 bbl daily. At least three-quarters of the increase is likely to find its way to markets in the United States and the balance to markets in Canada. The Transmountain pipe line throughput is expected to rise a further 20 per cent, though British Columbia refineries are likely to take somewhat less than last year. United States markets served by the Interprovincial pipe line are expected to expand sharply to some 54,000 bbl daily, while the Ontario markets may also increase. The prairie market should see some 7500 bbl daily added to consumption.

This expected 1956 production of 157,000,000 bbl will actually amount to two-thirds of estimated 1956 Canadian oil consumption, compared with production of 57½ per cent of consumption last year. Thus Canada is steadily moving to a position of self sufficiency in oil.

The important aspect of this is that, instead of reaching this position the hard way by cutting wellhead prices across the board in an effort to displace foreign oil in the Montreal markets via the west-east pipe line system, self sufficiency is being attained the natural and economic way. This is by gradual acceptance by the industry in both nations of the advantages of disregarding the international boundary, Canada serving U.S. markets in the Pacific Northwest and the Midwest, thus gradually building up an export movement in the west towards balancing the imports of foreign oil for the Quebec and Maritime areas.

Advantages of this "Continental Concept" are realized by the U. S. Administration, and supported by both it and the many major independent oil producers who have substantial interests in Canadian oil companies. Recently completed U.S. refineries close to the Canadian border are designed for operating on Canadian crude, and they are already connected up by pipe lines from Canadian sources.

This trend is important in two ways. It creates added incentive for Canadian producers and saves them from having to cut prices and build further long east-west pipe lines. It adds also to continental security by making fuel supplies available to the nearest markets regardless of boundary lines. The importance of the shorter pipe lines to national defense is not to be overlooked.

Industry Leaders Optimistic

Canadian Petroleum Institute President Vernon Taylor, addressing the Canadian Construction Association in Winnipeg last January, predicted that the provision of adequate outlets for Canada's natural gas would act as a stimulus to the western oil industry which had, as it were, to "fly on one wing" due to the absence of an economic outlet for gas. He forecast reserves of 5 billion barrels by 1960, with the potential or MER reaching a total in excess of a million barrels per day.

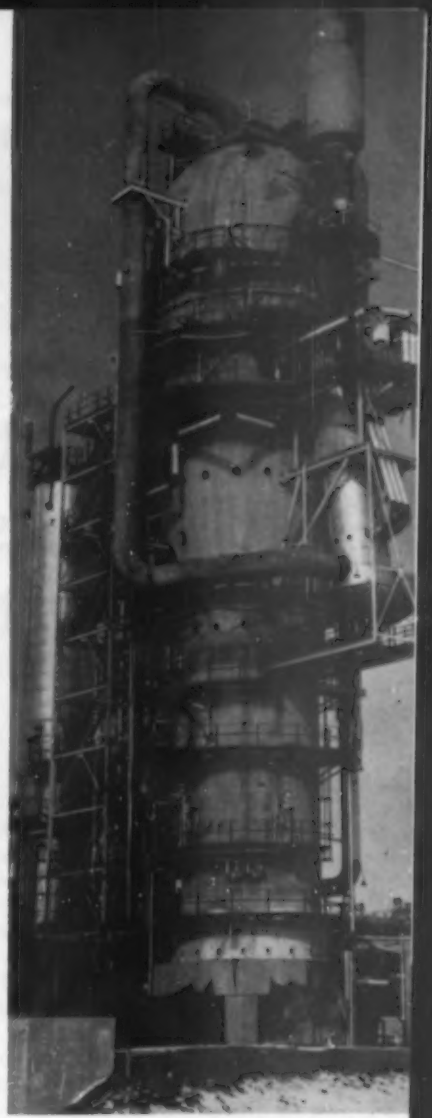
Canadian oil executives have been vying with one another in optimistic long-term predictions for Canadian oil in their briefs to the Royal Commission on Canada's Economic Prospects. President M. S. Beringer of British American stated exploration and development over the next 25 years would call for investment of another $10 billion. Liquid petroleum requirements by 1980 would rise to 780,000,000 bbl per year, based on a gross national production of $70 billion and on a Canadian population of 28,000,000 living in 7,000,000 dwellings and driving 12,000,000 automobiles, three times the present number on the road. Reserves would climb to 10 billion barrels of liquid hydrocarbons.

Imperial Oil's J. R. White, forecasting a 25-year growth in Canadian energy requirements and how much of the market for it would be supplied by petroleum products, predicted energy requirements would double and the demand for petroleum products would triple by 1980. The demand for Canadian Crude, he believed, would multiply 6 to 8 times the present 352,000 b/d, to between 2 and 3,000,000 bbl daily, depending upon the rate of development of export markets. By 1980, oil would be supplying some 62 per cent of Canada's total energy requirements, compared with approximately 48 per cent as of today. Reserves of between 23 and 30 billion barrels might be found, of which 10 to 13 billion will have been produced by 1980. Investment of some $20 billion would be needed to achieve these results, he said.

Big Future for Natural Gas

Production of natural gas in Canada has grown threefold over the past 10 years, from 48½ billion cubic feet in 1945 to 163 billion in 1955. Close to 85 per cent of the total is produced in Alberta, 8 per cent in Ontario, and most of the balance in Saskatchewan. Another 30 to 35 billion feet annually is being wasted from flares in Alberta alone, pending an outlet to markets outside the province.

Gas reserves, in spite of the lack to date of incentive to exploration, are increasing much faster than production.



—Courtesy British American

A new $4,000,000 catalytic reformer will be added at B-A's Clarkson, Ontario, refinery in 1956. Here is Clarkson's orthoflow catalytic cracking unit—first of its kind in the world.

Reserves in the four western provinces increased during 1955 by some 2 trillion feet to a total of 22 trillion feet. About 18 trillion of this total is in Alberta, with another 3 trillion in British Columbia and one trillion in Saskatchewan.

That the prospects for expansion in the use of Canadian natural gas are tremendous is shown by the disparity between its use in Canada and in the United States. Up to two years ago, natural gas filled only some 5 per cent of Canada's energy requirements, compared with 23 per cent of U.S. energy consumption.

Now, after more than 8 years of indecision and lack of confidence on the part of the federal and provincial governments, in sharp contrast to the

READ WHY SO MANY ENGINEERS AND FIELD MEN SPECIFY BOSTON HOSE AND BELTING

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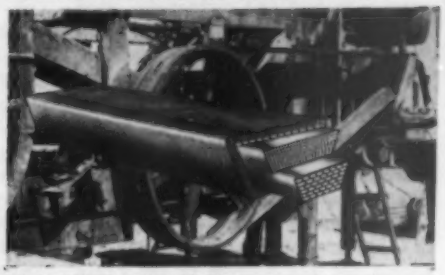
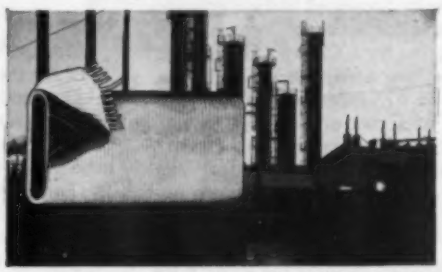
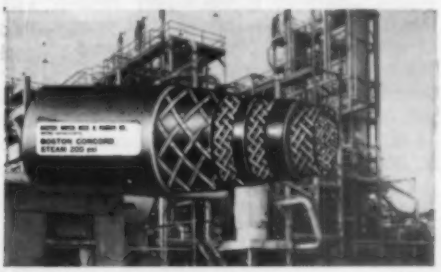
BOSTON TANK TRUCK AND FUEL OIL HOSE: Boston's seamless, synthetic tube won't flake or soften because it is unaffected by gasoline, oil, and other fuels. That means more rapid fuel transfer under all conditions. Your Boston Man will help you select the right hose for your jobs.



BOSTON V-BELTS: Muscles of tough, special cord brace *all* Boston V-Belts against slippage and shock loads. That's why they require less maintenance than other belts, deliver power more smoothly, efficiently and economically. Get the right belt for your job from your Boston Man.



BOSTON CHEMICAL AND FIRE HOSE: Boston's complete line of chemical and fire hose lasts longer even under the toughest conditions. That's because every Boston hose is designed for a specific job, engineered to do that job more effectively. Put Boston hose to work to protect your plant!



BOSTON STEAM HOSE: Built with safety to spare, Boston Steam Hose eliminates breakdowns and handling problems on cleaning and maintenance jobs; Boston's complete line of wire-reinforced and wrapped fabric steam hose is made with time-tested, heat-resistant compounds.

BOSTON SERVICE STATION HOSE: Air hose and gasoline Curb Pump hose used in service stations must absorb rough handling, weather, dirt, grease. Boston hose is designed to take this kind of punishment. There's a full line of Boston maintenance hose for air, water and steam applications.

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policy of confidence and ability of the industry to find and market the great sources of Canadian crude oil, which the nation accepted without question, Canadian natural gas export is assured to the Pacific states.

Westcoast Approved by FPC

Westcoast Transmission Company and Pacific Northwest Pipeline Corporation finally won Canadian and FPC approval in November, 1955, for joining the gas reserves of the Peace River Areas of northern Alberta and of British Columbia with the U.S. supply from the San Juan Basin of New Mexico. The project will serve markets in Washington, Oregon and Idaho and ultimately San Francisco, California, as well as Vancouver and the interior of British Columbia. It will supply 308,000,000 cu ft daily the first full year of operation, 250,000,000 to United States and 58,000,000 to British Columbia markets. Second-year deliveries will reach a total of 382,000,000 cu ft, U. S. taking 300,000,000 and Canada 82,000,000.

Construction has already started through the lower Fraser Valley near Vancouver. Orders have been placed for 75,000 tons of 30-in. pipe with a British pipe manufacturer, sufficient for the first season's construction on the 1000-mile line to the U.S. border and a spur to serve Vancouver. The project is scheduled for completion in 1957. The Canadian portion of the project involves expenditure of $142,000,000.

Westcoast will spend some $100,000,000 on pipe line construction during the current year, while another $13,000,000 will be spent on a gathering system, development drilling and a scrubbing plant at Peace River. The British Columbia Electric will spend about $18,000,000 for gas distribution lines, and Inland Natural Gas plans an additional outlay of some $5,000,000 for gas distribution in other cities and towns in British Columbia's interior.

Trans Canada Faces Hurdles

Trans Canada executives and representatives of their sponsors met with government officials in Ottawa last April, but failed to bring agreement on normal financing. Several gas producers failed to sign up, objecting to implied government control in the Ottawa offer to help. Trans Canada asked a guarantee of interest for the first few difficult years, but the government refused, demanding the financial plan be altered to spread ownership over a wider group, suggesting less borrowing and more equity financing, and favoring convertible debentures.

Though Trans Canada reluctantly accepted, several of the large Alberta producers decided they wanted no part of the deal, where a government agency would be in a position to control the company.

Following this abortive attempt, the summer of 1955 saw great activity behind the scenes by Trans Canada. In August, a sales contract was signed with Tennessee Gas Transmission Company, subject to FPC approval, of 200,000,000 cu ft daily to be delivered at Emerson, Manitoba, to be doubled when gas was available. The route through northern Ontario was changed to pass through the clay belt. Negotiations with Hydro Quebec on distribution lines in Montreal progressed, and in September the company's permit was extended to April 30, 1956.

A bill, announced last November and recently presented in the Canadian Parliament for approval, proposes the construction by a Crown Company of the pipe line across the initially unproductive 675 miles northern Ontario section, at a cost of $118,000,000, in which the government of Ontario would contribute $35,000,000.

This would be leased to Trans Canada for 10 years and ultimately purchased. Trans Canada has announced its intention of building the western leg as far as the Ontario border in 1956, as well as the extension of the Niagara-Toronto pipe as far as Montreal and placed a $30,000,000 order for pipe.

Billion Dollar Job

Sizes of the pipe line will be 34 in. diam to Winnipeg and 30 in. through to Toronto. From Toronto to Montreal it will be 24 in. with a 20-in. branch from Morrisburg to serve Ottawa. The entire pipe line will be buried to a minimum of 2½ ft between ground level and top of pipe. The ten compressor stations along the line will be powered with gas from the pipe line itself. These will deliver some 105,000 hp to handle peak-day export from Alberta of 620,000,000 cu ft per day.

The line will make some 86 railway crossings and 162 highway crossings. There are 110 river crossings as well as 240 crossings of creeks and streams. Major rivers to be crossed are the South Saskatchewan, Red, Winnipeg, Nipigon, Abitibi, French, Grand, Trent, Rideau and Ottawa rivers. With the relocation via Nipigon and Hearst to Kapuskasing, the line now will pass through the clay belt with exception of some 400 to 450 miles through the Precambrian shield between the Manitoba-Ontario border and Nipigon.

Cost of the entire stretch from Alberta to Emerson, Toronto, and Montreal may reach $375,000,000. The trunk gathering lines in Alberta will be built in three stages at a cost of some $47,000,000. Other production facilities in Alberta will cost $250,000,000, while distribution systems and sales programs in the various cities to be served will cost another $350 to $400,000,000, or a total of over $1 billion.

Steel shortages may delay this spring's expected start in the West, according to a recent statement by the Hon. C. D. Howe, Federal minister of Trade and Commerce. All the 34-in. pipe line has been ordered for the 700-mile western leg, he said, but a start would depend upon whether Trans Canada could assemble not only all the pipe but valves, fittings, and compressor equipment under conditions of actual steel shortage. Pipe has also been ordered for the 350-mile stretch between Toronto and Montreal.

Next Few Weeks Critical

With the deadline set for the end of April for proof of ability to finance the project, and assuming passage of the bill proposing formation of a crown company to build the northern Ontario gap, what is likely to happen? C. D. Howe stated last November that Trans Canada . . . "had until May 1, 1956, to demonstrate . . . that it has arranged for finances and commitments to carry through its entire construction program." A week later in Calgary, he added—"If it cannot demonstrate this, the government must reconsider its policies in the light of circumstances then prevailing."

Normal financing within this time limit would be admittedly most difficult if not an impossible undertaking, particularly in view of the scant hope of FPC approval beforehand. In the hope of retaining its permit, however, Trans Canada might raise sufficient funds elsewhere, perhaps through the assistance of Tennessee Gas Transmission and Canadian Gulf.

Should this course prove impossible or fail to receive government acceptance, a choice would have to be made of extending the interim permit anyway, thus losing another construction season, or of devising some other plan of financing, involving some form of government guarantee or subsidy.

Another alternative would be to cancel Trans Canada's permit and reopen negotiations with other pipe line applicants. Trans Canada's expenditures and progress to date would seem to preclude such a move. The only remaining choice would appear to be for the Canadian Government to combine with the Alberta, Ontario, and Quebec Governments, possibly with Saskatchewan and Manitoba as well, as their interests appear, in financing and building the entire pipe line from Alberta to Toronto and Montreal as a national undertaking with public funds. ★ ★

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Lowest Cost Per Horsepower Installed

Expanding Station Uses . . .

PACKAGED COMPRESSORS IN 5 YEAR PROGRAM

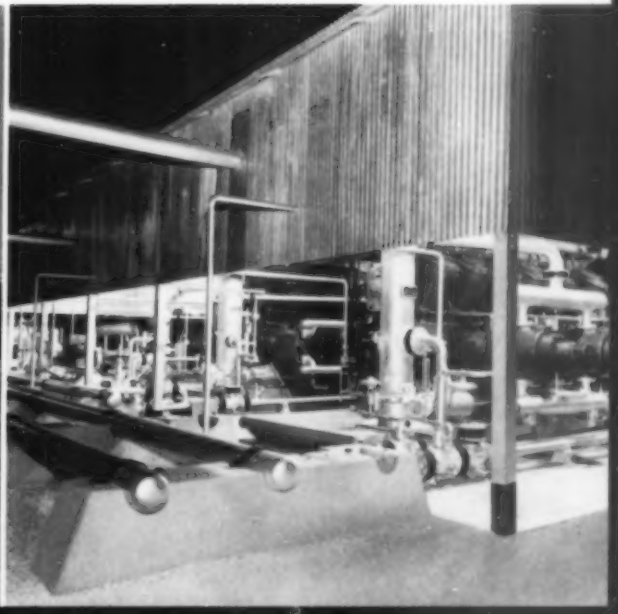
R. E. SMITH planned his Carthage Field compressor station for economical step-by-step expansion by utilizing packaged compressors. Now boosting gas from 200 psig to 1,300 psig at the rate of 10 mmcfd, the station has grown from a single 220 h.p. Beaird-Ingersoll-Rand Compressor Plant to three units with a total of 1320 h.p. all supplied by Beaird to meet increasing needs.

Originally designed with piping and connections for additional units, the station added the second compressor, a 440 h.p. Beaird 8SVG, when new wells were tied into the station. The third, a 660 h.p. Beaird 12SVG, was installed when wellhead pressures dropped and two-stage compression became necessary. At present only the largest and one small unit are needed, but as the pressures drop still further all three will be used to follow the suction on down through final production stages.

Fully automatic and designed for unattended operation, the station has required no increase in personnel to handle the added units.

Let us show you how packaged compressors can provide the most economical means of enlarging your present compressor station.

R. E. SMITH CARTHAGE FIELD COMPRESSOR STATION—equipped with three Beaird-Ingersoll-Rand gas engine driven packaged compressor plants, Young radiators and all necessary controls. Beaird packaged compressor plants are available in a range of sizes from 110 to 660 h.p.



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Pumping Progress Report

FOR PETROLEUM ENGINEERS

An advertisement prepared by the Aldrich Pump Co., Member of Hydraulic Institute, U.S.A.

PUMPING LIQUID BUTANE AND PROPANE is a typical operational headache successfully handled by the Aldrich Pump Company Engineers. It was a particularly tough pumping problem for one large pipe line company; they had to move butane 186 miles — from a Texas oil field to a Gulf Coast refinery.

PUMPING LIGHT-GRAVITY FLUID AT HIGH PRESSURES required the positive displacing action of conventional reciprocating pumps plus the flexibility of capacity provided by centrifugals. And Aldrich Engineers knew the answer — the Aldrich-Groff Controllable Capacity "POWR-SAVR" Pump.

STEPLESS STRAIGHT LINE CONTROL OF CAPACITY, from zero to rated maximum output, was possible with the "POWR-SAVR". Pump delivery was automatically controlled to suit varying requirements and power consumption became nearly proportional to the rate of output, affording desirable power savings.

SURGE TANKS WERE ELIMINATED, due to the "POWR-SAVR's" ability to meet immediate changing line conditions. This eliminated associated evaporation losses, co-mingling of different batches, and much of the danger of handling highly flammable material. Gone, too, was the need for bypassing to handle excess quantities of pump output.

UPRIGHT DESIGN of the "POWR-SAVR" places discharge valves directly over the plungers and inlet valves at one side. Efficient valve action permits the pump to operate at the high rate of 240 rpm. Another design feature was the use of porcelain plungers, reducing packing and leakage troubles.

THE ALDRICH PUMP COMPANY has been solving the difficult pumping problems of American industry since 1902. We've never turned down a challenge — many of yesterday's tough pumping problems are today routine.

DATA SHEET 65A, describing the Aldrich-Groff Controllable Capacity "POWR-SAVR" Pump will be sent to you on request. Or our representative will be glad to call. Address your request to: The Aldrich Pump Company, 26 Pine Street, Allentown, Pa.

Aldrich-Groff Controllable Capacity "POWR-SAVR" Pump suitable for pumping butane and other light-gravity fluids.

... for your tough pumping problems specify ALDRICH

This machine is ideal for pumping light-gravity fluids at medium and high pressures. It combines features of superior efficiency and positive displacing action of reciprocating pumps with the flexibility of capacity of centrifugal pumps. A unique, reliable mechanism controls the plunger-stroke from zero to rated output without change of speed of power source, providing desired savings in power plus top efficiency.

Typical Applications for the Aldrich-Groff "POWR-SAVR" Pump:

Pipe Line Service **Process Charging**
Boiler Feeding **Oil-burner Supply**

Write for Data Sheet 65A, describing the features of the "POWR-SAVR" Pump. Or, if you prefer, our representative will be glad to call.

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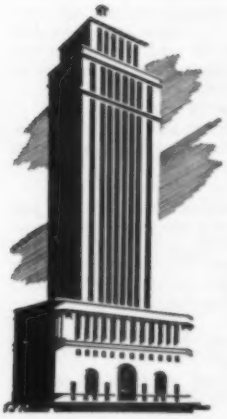
The Royal Bank of Canada, Canada's largest bank, whose clients include many of the most prominent firms in the field, offers exceptional services to the petroleum industry. Its Oil and Gas Department, manned by experienced officers in close touch with the situation, provides information, guidance and practical aid to prospective entrants.

In Alberta, Canada's oil-rich province, Royal Bank branches number 63, including Calgary, Edmonton, Leduc, Devon, Redwater, Drayton Valley and Turner Valley. In Saskatchewan, Manitoba and British Columbia, branches total over 200. *We do not provide information on oil securities.*



The Royal Bank issues bulletins from time to time covering statistics, regulations, tariffs, oil and gas financing, and kindred subjects. These are free on request. For a list of current bulletins write to The Royal Bank of Canada, Oil and Gas Department, 409—8th Avenue West, Calgary, Alta.

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LAUGH with BARNEY

A dear old lady went into a pet shop to price some dogs.

"You can have that small bitch over there for $25," said the clerk pointing, "or that larger bitch for $35."

The old lady frowned as the man spoke. "Why, madam," asked the clerk, "aren't you familiar with the term 'bitch'?"

"Why, certainly," replied the lady haughtily, "but never before have I heard it applied to dogs."

Then there's the girl who hasn't much "upstairs" — but what a stairway!

A small porcupine was taking a morning walk. Suddenly he stepped back into a cactus plant and asked: "Is that you Ma?"

"Johnny, what are you doing?"

"Nothing much. With you and Jesus and Santa Claus watching all the time, I just can't do much.

A young man stared into the mirror one morning and noted his bloodshot eyes, resolved to never go into a bar again. That television, he muttered, is ruining my eyes.

A man traveling in an upper berth in a pullman car was aroused in the night by a tapping on the bottom of his bunk. He peered over the side and found the lady below trying to get his attention.

"I hate to disturb you," she said, "but I'm cold. I though you might have a blanket you could spare."

"Are you married?" the man asked.

She nodded.

"Well," he said, "in that case let's get warm like married people do."

"What do you mean?" she asked.

"Get your own damn blanket!" he snarled.

A chap ort t' save a few o' th' long evenings he spends with his girl till after they're married.

Farming looks nice — from a car window.

A group of elderly men in a certain city decided to start a social club. They called it the "Over-Eighty Club." The local newspaper thought this was newsworthy enough and sent a reporter to interview the club's president.

"Is it true that a man must be at least eighty before he can join?" the reporter asked.

"Yes, but last week, we let two fellows in who were only seventy-eight," the president said.

"What was the reason for that?"

"Well," the old man answered, "every organization needs some young blood!"

Mama went across the street to chat with a neighbor, leaving Papa alone with Junior. Papa buried himself behind a newspaper, and forgot all about the baby until he heard a series of thumps and an ear-piercing wail.

"Clementine!" called Papa excitedly to his spouse. "Come here—Junior just took his first twenty-one steps!"

Co-ed to new boy friend: "Why did you break your engagement?"

Boy Friend: "She wanted to get married!"

Jane: "Sometimes my dad takes things apart just to see why they won't go."

James: "So what?"

Jane: "So, you'd better go."

The TV repairman was trying to locate the trouble in a friend's set. The six-year-old had watched the whole operation, fascinated. "I'll bet," he said, "if you'd clean out the dead cowboys from the bottom of the set it would work again."

Conscience doesn't keep you from doing anything wrong, just keeps you from enjoying it.

The husband was curious. "Why do you weep and sniffle at a movie over the imaginary woes of people you never met?"

The wife replied, "The same reason why you scream and yell when a man you don't know slides into second base."

Wife: "What do you mean by coming home half drunk?"

Husband: "It's not my fault—I ran out of money."

ANOTHER PIPELINE GATHERING PUMP

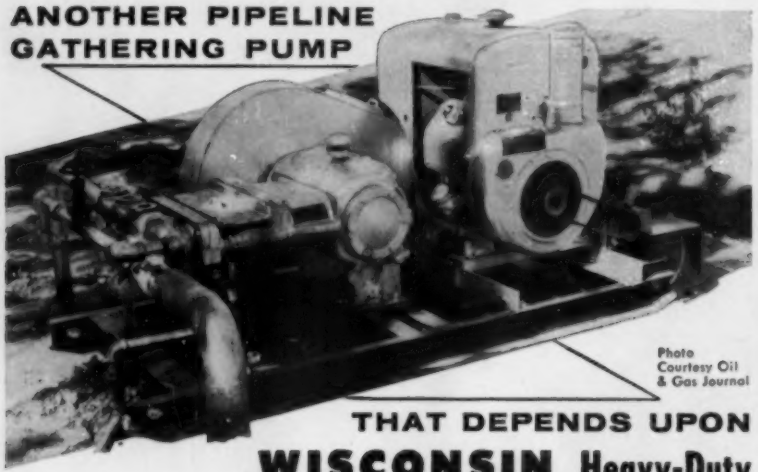

Photo Courtesy Oil & Gas Journal

THAT DEPENDS UPON

WISCONSIN Heavy-Duty Air-Cooled ENGINE POWER

Operating in the Purdy Field, in Garvin County, Okla., this compact pipeline gathering unit, powered by a Model VF4D Wisconsin Heavy-Duty Air-Cooled Engine, serves a major pipeline company. It stays on the job in all weather, at all seasons and requires a minimum of human attention.

The Wisconsin Power Unit represents the most advanced standards in heavy-duty design and construction. It is a 3¼" x 3¼" four-cylinder V-type engine, rated at 15 to 25 hp. in a 1400 to 2400 rpm range, with tapered roller main bearings, pump-circulated lubrication with an individual oil stream to each connecting rod, and is furnished with Stellite-faced exhaust valves, Stellite valve seat inserts, positive type valve rotators and replaceable valve guide inserts. Flywheel fan supplies trouble-free cooling at all temperatures from sub-zero to 140° F.

Wisconsin Air-Cooled Engines rate "first choice" for many types of oil field utility units, delivering "Most H.P. Hours" of on-the-job service, with minimum maintenance and servicing.

You can't do better than specify "WISCONSIN" for your equipment.

Model TFPD Wisconsin Oil Well Pumping Engine

Get the details about this 2-cylinder Wisconsin Heavy-Duty Air-Cooled Oil Well Pumping Engine, with built-in HIGH MOMENTUM FACTOR.

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World's Largest Builders of Heavy-Duty Air-Cooled Engines

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New Mid-Continent Store at Harvey, La.

Completely stocked with the finest equipment and supplies for deep drilling offshore and inshore, the new Mid-Continent Supply Store at Harvey means faster-than-ever service along the Louisiana Gulf coast.

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THE WORLD'S LARGEST INDEPENDENT OIL FIELD SUPPLY COMPANY

PERSONALS

Fred H. Moore, assistant to the president of Magnolia Petroleum Company, has been promoted to executive vice president and manager of Mobil Oil of Canada, Ltd., with headquarters at Calgary, Alberta. Moore succeeds **H. R. Moorman,** who is being moved to Socony Mobil Oil Company's general offices in New York City. Magnolia and the Canadian organization are both affiliates of Socony Mobil Oil Company, Inc. Moore received his bachelor's degree in geology from Texas Technological College in 1930 and his master's degree in geology from the University of Virginia in 1931. He joined Magnolia in 1935 as a field geologist in Oklahoma.

F. H. Moore

Walter C. Holloway, staff official of the Kin-Ark Oil Company, has been elected to the company's board of directors. Holloway joined the Kin-Ark last November. He had previously been employed by the former Lawton Oil Company in Magnolia, Arkansas, and the Murphy Corporation, an oil firm of El Dorado.

Kin-Ark board members re-elected are: **Curtis A. Kinard,** Kin-Ark, president and chairman; **Jeff Davis,** Davis and Allen, attorneys, El Dorado; **Richard C. Noel, Van Alstyne,** Noel and Company, New York; **J. T. Ponder,** executive vice president, and **K. D. Lankford Jr.,** chief geologist.

Wayne O. Watts has been elected president of the North Texas Oil and Gas Association, succeeding **D. C. Norwood.** Other new officers are: first vice president, **Ralph O. Harvey Jr.;** second vice president, **James W. McCutchen,** and executive vice president, **Geroge W. Anderson Jr.**

Herman P. Taubman, Tulsa, Oklahoma, founder and president of the Buffalo Oil Company, has been named chairman of the board and chief executive officer. Succeeding him as president will be his son, **Morris B. Taubman,** Fort Worth, Texas, who has been executive vice president. **W. W. Lomerson,** former assistant to the vice president, has been made vice president and will continue as manager of the southern region.

Frank A. Schultz, independent Dallas, Texas, oil operator, has been elected to the board of directors of Three States Natural Gas Company. Schultz is a former vice president for exploration of Delhi Oil Corporation and will remain an executive of Canadian-Delhi. **Joseph P. Donahue Jr.** has been named secretary and treasurer replacing **Miss Margaret Clark,** who has resigned. Donahue has been assistant secretary and treasurer since 1953.

T. A. Helling, president of El Dorado Refining Company, has been elevated to chairman of the board. His successor as president is **George J. Peterschmidt.** The position of board chairman has been vacant since the death of Charley G. Yankey two years ago.

Chester E. Weger, vice president and a director of Cities Service Refining Company, has been elected a director of the parent company, Cities Service Oil Company. He is also vice president and treasurer of other subsidiary companies.

Wallace W. Wilson, chief of the reserves and evaluation section and formerly chief reservoir engineer of Continental Oil Company at Houston, Texas, has joined the Continental Illinois National Bank and Trust Company of Chicago, Illinois, as petroleum engineer in the bank's expanding oil and gas department. Before joining Continental Oil, Wilson worked on secondary recovery problems for the California Corporation. Wilson obtained his degree in geology at Pomona College.

Nelson Puett has been appointed chairman of the Federal Petroleum Board at Kilgore, Texas. **Leo Hart** has resigned as chairman because of ill health. Pruett has had more than 15 years of experience as an examiner in Connally Act administration work and as a member of the Federal Petroleum Board since September 1952.

John C. Askam, former chief safety engineer of the Ohio Oil Company, has been appointed assistant to the vice president of administrative services. Askam will serve as liaison with the military in the capacity of security officer for the company. He will be responsible for investigating all factors pertaining to the protection of company property and developing plans to be followed in cases of emergency. **H. C. Walker** has been appointed acting supervisor of the safety department in addition to his responsibilities as assistant manager of the personnel department.

J. C. Askam

Olin Culberson, veteran Texas Railroad Commission member, will be honored by the Texas Independent Producers and Royalty Owners Association in Austin, Texas, at the association's tenth annual membership meeting in April. Culberson will receive the "TIPRO Recognition Award" for his contributions to the oil industry as a whole and for his effort in preserving conditions vital to the welfare of independent producers and royalty owners. He is credited by many as being responsible for the formation of this association.

J. E. Roth has been appointed administrative vice president for production of Tide Water Associated Oil Company, with headquarters in San Francisco, California. Roth has been associated with Tide Water since 1924 and had served as general manager of the company's central division in Tulsa, Oklahoma, since 1954. **Charles R. Brown,** vice president of Tide Water, has been named to succeed Roth. Brown, employee of the company since 1917, formerly was assistant general manager of the central division.

Thomas J. Freeman and **James F. Hartnett** were recently promoted in the public relations department of Tide Water's eastern division office in New York City. Freeman, formerly editor of the company's eastern division employee publication, *Tide Water Associated News,* and winner of the Freedoms Foundation's George Washington Honor Medal last year, was named public relations assistant. Hartnett, editor of Tide Water's dealer publication, *Flying-A News,* was named editor of the employee paper.

Charles S. Atwell, vice president of South American Gulf Corporation, a subsidiary of The Texas Company and Socony Mobil, has been elected chairman of the board of Mile High Oil Company, Inc., whose headquarters are in Pueblo, Colorado. He had been head of all foreign construction work for Texaco's export department for many years and has crude oil production of his own. **Willard D. Egolf,** Washington, D. C., attorney, has been named vice president and general counsel of Mile High. Egolf has formerly been in the oil equipment and refinery advertising business and now has his own oil production in West Virginia, Wyoming, Oklahoma, and Texas.

Roger S. Randolph has been elected as a director of White Eagle Oil Company to replace **Eugene O. Monnet,** who has retired. Randolph, tax law specialist, is a partner in the law firm of Conner, Winters, Randolph & Ballaine. **Dr. Robert William Haigh** will move to Tulsa, Oklahoma, early in June as assistant to the president of White Eagle Oil. He has resigned from his position on the staff of the Harvard Graduate School of Business Administration.

Homer J. Livingston, president of the First National Bank of Chicago, has been nominated as a new director of Standard Oil Company (Indiana). Election will be held May 3.

F. Cushing Smith, assistant superintendent at Whiting refinery, has been promoted to a new position as assistant to the president of Standard Oil (Indiana), and **O. J. Glasman** has been made assistant manager of the company's organization department.

DEATHS

H. S. Woolner, 88, independent oil operator, died February 5 in a Long Beach, California, hospital after a brief illness. He had been an independent operator in California since the beginning of the Signal Hill Boom.

Dr. Robert Leigh Hewitt, 44, died recently in Bakersfield, California, following a heart attack. He was chief geologist for Trico Oil and Gas Company.

John J. Conry, 77, retired president of Carter Oil Company, died March 3 at his home in Tulsa, Oklahoma, after a long illness. He retired in 1941, having been associated with Carter and other Standard Oil Company (New Jersey) affiliates for 41 years.

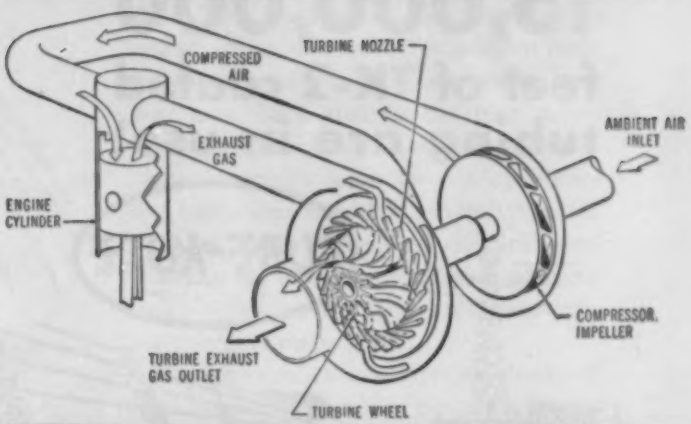
Nelson N. Clabaugh, 45, owner of the Clabaugh Drilling Company, died February 26 in an Oklahoma City, Oklahoma, hospital from a heart attack. He was also a partner in the CB Drilling Company.

Jack Ray, 81, pioneer oil field worker, died February 24 at Austin, Texas. He had been one of those who helped bring in the first well at Luling, Texas.

Caterpillar announces a TURBOCHARGED

D397 (SERIES D) 650 HP Maximum @ 1300 RPM AND D375 (SERIES D) 430 HP Maximum @ 1300 RPM

Compact, modern heavy-duty oilfield diesels for greater power, efficiency and economy!



The Cat D397 Turbocharged Engine

Both the D397 and the D375 are also available as *roots blown, naturally aspirated or spark ignited* engines.

The Turbocharger . . . Exhaust Gas and Air Flow

Another example of Caterpillar leadership in action! The Turbocharger, driven by the engine exhaust, utilizes energy which would otherwise be lost. It packs air into the engine according to engine load for greater efficiency.

As shown in the diagram above, engine exhaust gases turn the turbine, which drives the compressor . . . the compressed air then enters the cylinders. Final result: more power on less fuel.

More than eighteen years of research have gone into these two new CAT* Turbocharged Diesels. Incorporating metallurgical, mechanical and aerodynamic advances, they are engineered to deliver higher horsepowers and lower operating costs at reduced noise levels. Their advance-design features are also available in D397 and D375 Electric Sets and Marine Engines.

With these engines in the Caterpillar line-up, you now have an even wider choice of compact, modern heavy-duty power to meet your requirements. Get the complete facts about these two new Turbocharged Diesels from your Caterpillar Dealer!

Caterpillar Tractor Co., Peoria, Ill., U.S.A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

MODERN HEAVY-DUTY OILFIELD DIESELS

OIL and GAS TRADE NEWS

Rockwell Purchases Kansas Firm

Rockwell Manufacturing Company has acquired the assets of Locomotive Finished Materials Company at Atchison, Kansas.

The 84-year-old Kansas concern, largest Rockwell acquisition since the purchase of Delta Manufacturing Company 11 years ago, will continue under its present management as a major division of Rockwell.

Acquisition of LFM, with almost half a million square feet of production facilities in Atchison and in St. Joseph, Missouri, will bring Rockwell's volume for 1956 to more than $105,000,000 and will add approximately 1000 employees to the company roster. Plans for additions to the Atchison facilities have been approved, and further expansion in the area is under consideration.

New Additives Sales Group Set Up

Du Pont's petroleum chemicals division has established a new additives sales group with headquarters in Wilmington, Delaware. J. J. Mikita, former petroleum laboratory director, has been named sales manager of the new group.

New home for main office of The M. W. Kellogg Company will be consolidated in this new building in New York City after April 29. Pullman, Inc., Kellogg's parent company, will also have offices in the new building, as will Trailmobile, Inc., another Pullman subsidiary.

Patent On Air Mapping Device

W. S. Karr, executive vice president of Abrams Aerial Survey Corporation, has received notice that his application for a patent filed in 1952 has been approved. The patent covers equipment and a method for assembling a large aerial photo-mosaic map in small units and maintaining precision match of the units and geographical control over the entire area.

The invention is claimed to solve the problem of making an aerial map of a large area on a flat surface when the pictures actually are of the earth's curved surface. Such maps are made in quadrangles, the edges of which fall along parallels of latitude and meridians of longitude. The meridians of polyconic maps usually converge slightly, creating a problem to the mosaicers in making an accurate map.

With the Karr invention, the quadrangle configurations are cut from hard board to exact size and shape and then known control points indicated on their surfaces. The pictures are then mounted on the boards with care to keep the control points on each picture over the control points on the boards.

Morse Chain Acquires Denver Firm

Morse Chain Company, a Borg-Warner subsidiary, has announced the acquisition of Eberhart-Denver Company of Denver, Colorado, and its affiliate, the Spreco Company, of Chicago, Illinois.

Fred Eberhart, founder of Eberhart-Denver, becomes chairman of the board, and Stanley J. Roush will be president. Robert Bass will serve as vice president and general manager while John R. Mueller will continue as vice president and chief engineer. M. V. Bailliere Jr., secretary-treasurer of Morse Chain, will also be secretary-treasurer of the newly acquired company.

NOW...

15,000,000

feet of TK-2 coated tubing are in use!

TUBE-KOTE T.M. REG.

15,000,000 feet in use . . . twice as much as in 1954 . . . proof of TK-2 dependability in preventing oil field corrosion and paraffin troubles before they start.

Result: more oil companies *save* money by coating new and used tubing with TK-2 plastic before corrosion damage forces replacement.

Learn about TK-2 — why it is the lining companies specify for every major oil field, how it makes your first tubing cost your last, even in the most corrosive field. Write for new TK-2 literature.

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Pick a card ...any card

• • • On it you'll find the answer to a certain refinery tubing problem. These 24 different steel tube analyses are the result of over 60 years of work and research in the refinery field. Each analysis has been developed to counteract specific refinery conditions ranging from corrosion to high pressures and temperatures. Each analysis has been tested again and again in actual refinery service so that our engineers know its exact capabilities and limitations. In addition to the two dozen analyses shown here, other chemical compositions are available in tubular products, and a wide variety of temperature problems are presently under study.

So pick a card—the analysis you think will meet your refinery tubing needs. But, to be sure before you order, contact us. We have a technically trained Mill Service Force available to you for technical and operating assistance in meeting your tubular requirements. This Force is also available for consultation in the field. We might be able to save you money by selecting a better alloy, at lower cost, to meet your problem. Service is as much a part of our business as is selling pipe. Let us hear from you.

★ ★ ★

Write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

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Carbon	8 Cr, 1 Mo
Carbon, ½ Mo	9 Cr, 1 Mo
1 Cr, ½ Mo	12 Cr
1¼ Cr, ½ Mo	12 Cr, Al
2 Cr, ½ Mo	17 Cr
2¼ Cr, 1 Mo	18-8
2½ Cr, ½ Mo, ¾ Si	18-8 Ti
3 Cr, 1 Mo	18-8 Cb
5 Cr, ½ Mo	18-8 Mo
5 Cr, ½ Mo, 1½ Si	25-20
7 Cr, ½ Mo	3½ Ni
8 Cr, ½ Mo	5 Ni

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USS **NATIONAL SEAMLESS PIPE AND TUBES**

UNITED STATES STEEL

Ultrasonic Manufacturers Unite

Formation of the Ultrasonic Manufacturers Association has been announced by its newly elected officers and board of directors.

Organized by the leading manufacturers in this new and rapidly expanding field, the UMA will promote dissemination of sound and accurate information about ultrasonic equipment and its applications. UMA will assist the ultrasonic industry in adopting ethical practices in sales, publicity, and advertising. In addition, the UMA will aid its members in securing clear and realistic rulings from governmental agencies such as the Federal Communications Commission.

Officers of the association are: President, W. C. Potthoff, vice president, Aeroprojects, Inc.; vice president, Stanley R. Rich, technical director and vice president, The General Ultrasonics Company; secretary, Norman Branson, president, Branson Instruments, Inc., and treasurer, Jack Welch, general manager, machine tool division, Sheffield Corporation. Other directors are Dorr Wagner, Solar Manufacturing Corporation; R. B. Manning, Sperry Products, and Stanley E. Jacke, Detrex Company.

Hough Plant Expansion Underway

The Frank G. Hough Company, Libertyville, Illinois, has announced construction of a 55,000 sq ft addition to its plant. These new buildings, which are expected to be completed this year, will give the plant a total of 368,000 sq ft.

The new facilities will provide an area 32 times greater in size than the original property was when the company moved there from Chicago, Illinois, 16 years ago.

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Chicago, Ill.—Harry A. Jay, Suite 1090, Old Colony Bldg.
Denver, Colo.—Earl H. Jones & Co., 1863 Wazee St.
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Erie, Pa.—R. J. Maggi, Box 711
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Houston, Texas—Henry H. Paris Distributor, Inc., Box 932
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Mud Products, Inc., Sold

National Lead Company is acquiring the capital stock of Mud Products, Inc., Tulsa, Oklahoma, by exchange of its own shares of stock. Mud Products will continue under its present name in its normal business of distributing the products of the Baroid Division of National Lead.

Mud Products, its Beaumont, Texas, cement sales division, and Bomud Company, a subsidiary, distribute oil well drilling mud materials manufactured by Baroid Division.

Mud Products, will function with its present personnel under the direction of Ben R. Bourland. Emil R. Albert, Jr., former president of Mud Products, Inc. has accepted a new position as president and general manager of Rubarite, Inc., a subsidiary of National Lead, Bird and Son, and Goodyear Tire & Rubber Company.

Pipe Goes 'Piggy Back'

Use of the new rail and truck transportation called "Piggy Back Service" to ship coated and wrapped small-size pipe from mill to job has been announced.

First test run was made from the Youngstown, Ohio, plant of Hill, Hubbell and Company to the East Coast over the Erie Railroad.

This new method is said to speed delivery and eliminate extra handling. Pipe is loaded in special trailers that are pulled by truck, and is then put on the railroad flat cars. Thus the same load of pipe goes from plant to job without being reloaded. Special loading techniques developed by Hill, Hubbell and Company protect the pipe coating and wrapping enroute, and a simplified "Sling System"" speeds unloading at the jobsite.

Cleaver-Brooks Mobile Unit

Operating out of the Houston, Texas, and New Orleans, Louisiana, areas, a mobile unit will provide service and parts for Cleaver-Brooks Company waste-heat and vapor-compression evaporators in the Gulf area.

It is available night and day for service duty.

Beaird Buys LPG System Division

Purchase of the LP-Gas system division and manufacturing facilities of the Butler Manufacturing Company at Galesburg, Illinois, by The J. B. Beaird Company, Inc., Shreveport, Louisiana, effective April 2, has been announced.

A new manufacturing plant, utilizing Butler equipment plus the most modern machinery available for producing LP-Gas systems, will be built immediately in the general Galesburg vicinity.

Coordination of Butler's heavy midwestern distribution into Beaird's nationwide LP-Gas sales organization will be handled by Richard M. Meisenbach, manager of LP-Gas and NH-3 equipment sales.

Crose and Affiliates Sold

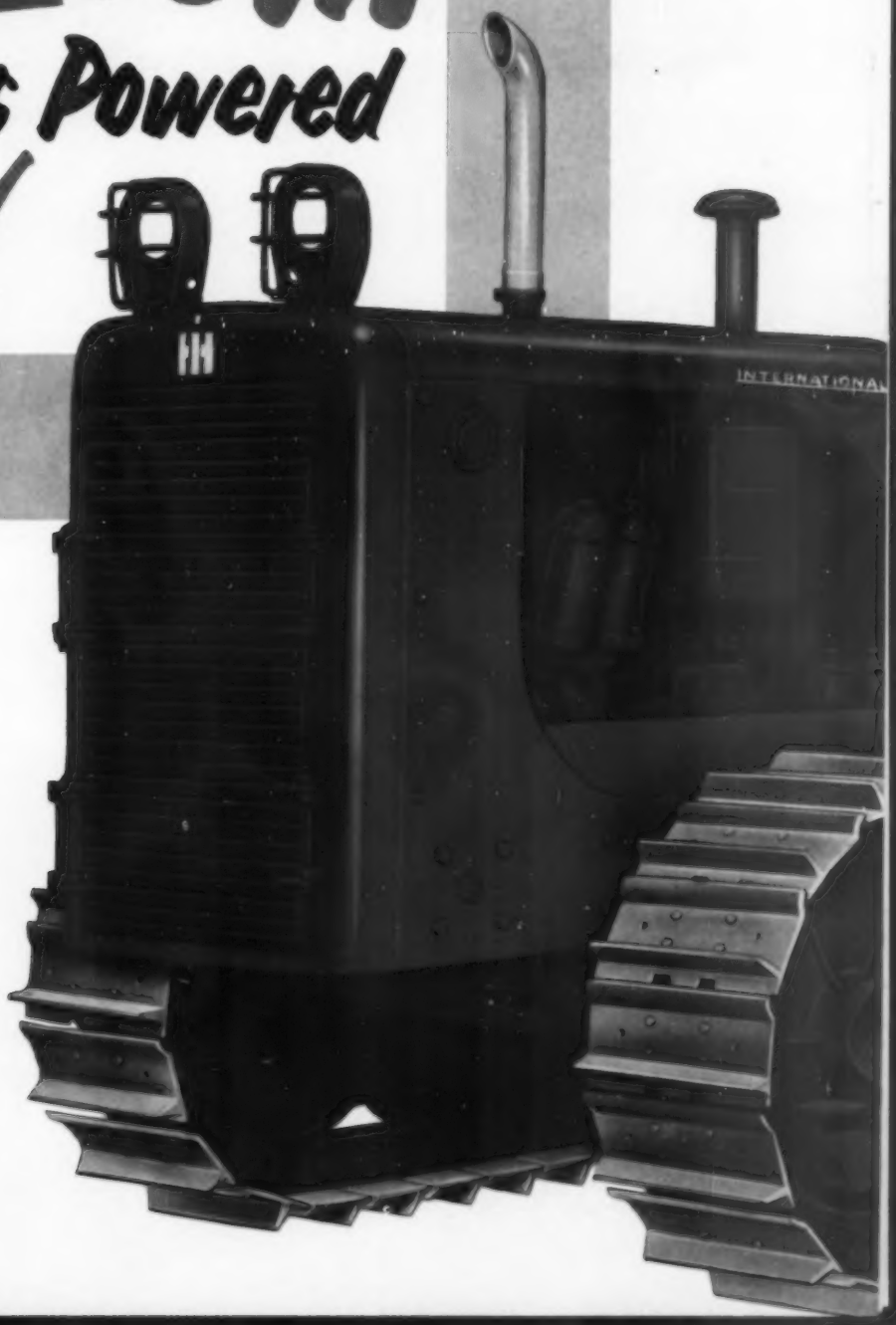
Purchase of M. J. Crose Manufacturing Company, Tulsa, Oklahoma, by Graham-Paige Corporation, New York investment firm, has been jointly announced.

Crose will continue to operate under its present name as a division of Graham-Paige, with no change in management or policies.

A Crose subsidiary, Pipe Line Anode Corporation, Tulsa, was included in the purchase, as was Crose-Curran, Ltd., Edmonton, Alberta, Canada.

NEW...

Bonus Powered too!



NEW

124 Net Engine Horsepower. In International Drott Machines, Engine develops 134 Net Horsepower.

182 Series

TD 18

TD-18 diesel (series 182) delivers 103 drawbar horsepower, with weight of 29,050 pounds (without equipment). All-weather electric starting, standard equipment. "New look" visibility, operating ease never before available. New heavy-duty, swinging-door type radiator guard is "standard"—for carrying heavy front-mounted equipment. Gives big tractor performance in pioneering under roughest conditions. Powers 3-yard International Drott Skid-Shovel, anywhere.

No costly delay from a "killed" or cold engine—you start fast! Famous International *gasoline-conversion* diesel starting—actual "in-seat" starting—is *standard equipment* on this new crawler line. With "push-button" ease, you get seconds-fast starting, whether the engine is cold, or stopped! And you're on the job seconds-fast, when minutes are dollars.

Cerametallic Engine Clutch Facings Save power, defy heat, prolong life! Uncomplicated, *familiar-to-all* engine clutch design of these new crawlers have *power-holding, heat-defying, long-lasting* Cerametallic facings. These facings reduce lever-pull up to 50%, provide amazing heat immunity, add service freedom, cut upkeep!

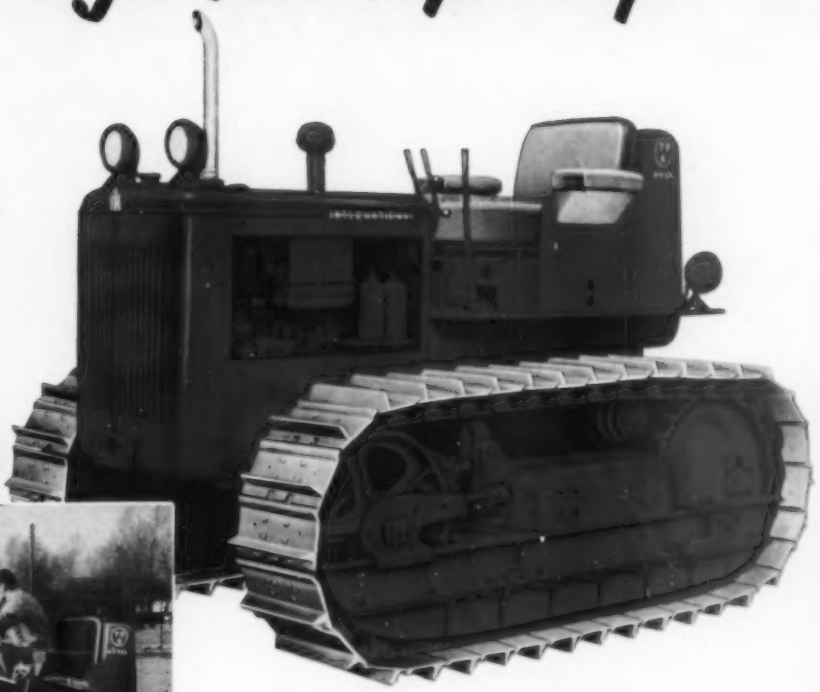
How . . . 500-hour lube intervals with new metal-to-metal, track roller seals! You save the time and expense of frequent inspections or lubrications, with the new *full-floating*, cartridge-type, track roller seals provided on the TD-24, TD-18, and TD-14. These precision-lapped, metal-to-metal seals are so effective they give you *safe* 500-hour intervals between roller lubrications!

Steps up a size... in job range and capacity!

50 Net Engine Horsepower. In International Drott Machines, Engine develops 55 Net Horsepower.

61 Series

TD 6

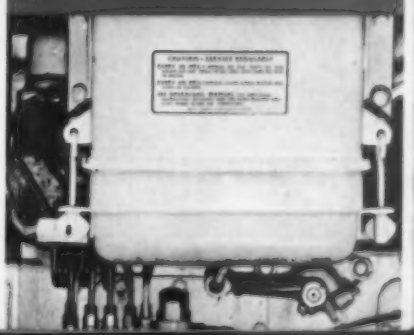


TD-6 diesel (series 61), 41.5 drawbar hp, up 23%! Steps up a whole size in work capacity and earning ability. Operating weight (5-roller model), without equipment, 8,890 pounds. Powers 1-yard International Drott Skid-Shovel or Four-In-One; serves as clean-up dozer unit on any-sized contract; versatility and low operating cost to do many sizes of jobs for every size of contractor.

Full-view, one-glance panel saves time—cuts effort! One quick glance at this new full-view panel, with centralized instrument grouping, gives the operator the instant check-up, to assure that lubrication, generator, and cooling system are "perking" for full production!

New Fold-over Seat Aids Fast, Centralized Servicing! New fold-over seat of the TD-6 and TD-9 models allows operator to give you the time and convenience advantages of centralized steering clutch assembly servicing. Lubricant fittings are conveniently grouped and fully accessible!

Thorough air filtration assured by new under-hood cleaner! Instead of being "in your lap," or a knee-bumping obstruction, air cleaners of the new International crawlers are side-mounted—for easy accessibility, yet out of the way. They have big capacity and high efficiency, too, for positive air filtration!



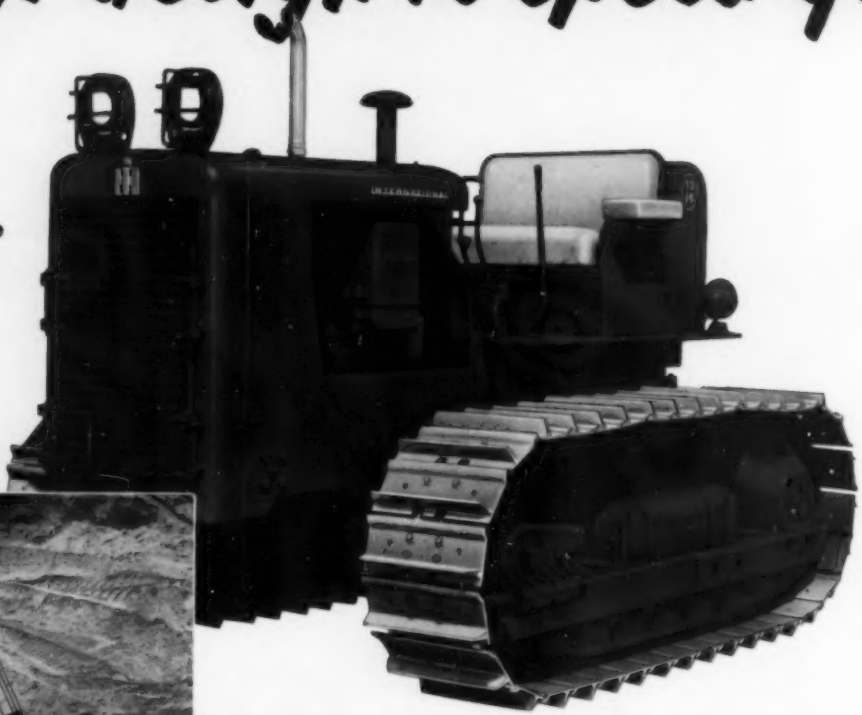
International® Crawlers gi

plus new design to speed yo

95 Net Engine Horsepower.

142 Series

TD 14



TD-14 (series 142), 78.5 drawbar hp; weighs 21,095 pounds (without equipment). Features "new look" engineering, job-speeding visibility, new equipment-carrying and operating strength. All-weather electric starting, standard equipment. It's a fast, responsive, big-capacity dozing tractor. Powers 2¼ cu. yd. International Drott Skid-Shovel or Four-In-One; 15-ton capacity Superior Pipe-Boom; other similar-sized equipment.

Control Fewer Visibility adds operating efficiency! See how new International crawlers are streamlined for complete job-control visibility. Seat is amply high to provide full view of equipment, terrain, and variations requiring operator action, to maintain efficiency.

Clean, safe deck cleared for action! Look down on that safe, clean, flush deck—a platform for full production. The wide, man-size seat is fully-adjustable; foam rubber padded. Instruments centralized for one-glance check-up! Even a cigarette lighter is provided, to prevent needless stops!

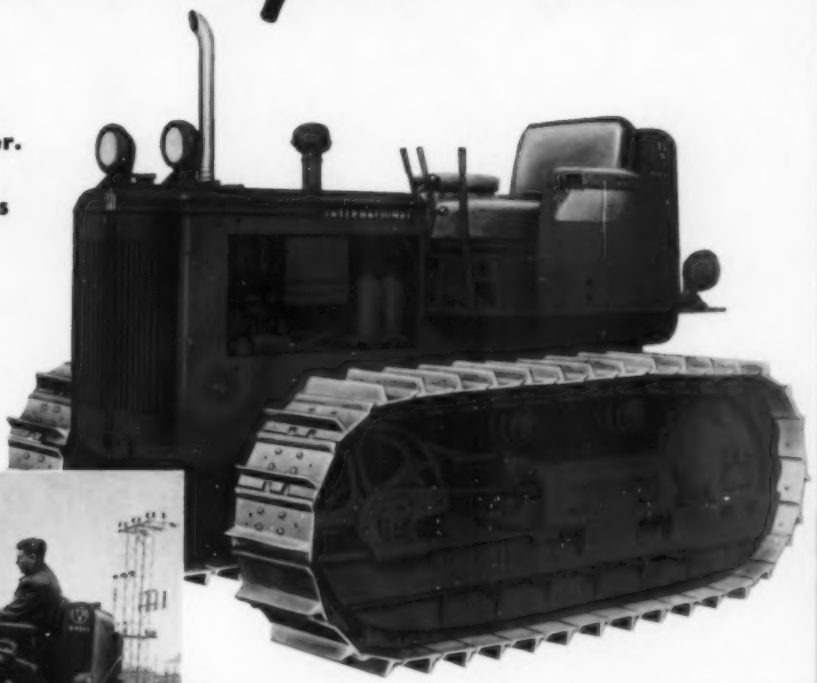
Pressurized Closed Cooling System for Positive Performance Protection! New pressurized cooling systems provide fast warm-up under thermostatic control—and positive *ideal* temperature control with forced circulation through full-length jackets. That aids clean combustion, guards oil film strength, protects performance. Radiator core assembly is easily-removable, without disturbing radiator guard or mounted equipment.

ive you Bonus horsepower—
our jobs, control your costs!

66 Net Engine Horsepower. In International Drott Machines, Engine develops 71 Net Horsepower.

91 Series

TD 9

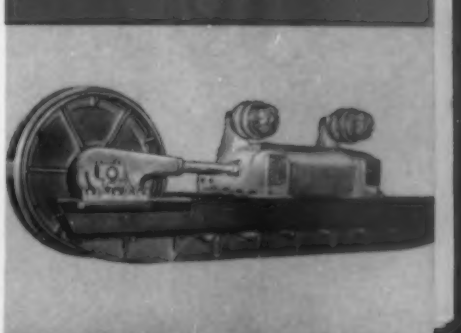


TD-9 diesel, (series 91), delivers 54.5 drawbar hp—up 32%. Operating weight (5-roller model), without equipment, 12,000 pounds. Now up in a new heavy-duty job range. New power is backed by new power train and track frame strength, new operating and servicing ease. Powers International Drott 1½ cu. yd. Skid-Shovel and other equipment requiring similar power.

480-hr. full-flow lube oil filters guard bearings, cut upkeep! Every drop of oil on its way to lubricate moving engine parts must pass through these new abrasive-trapping micron-type filters—with the capacity, strength, and efficiency to give 480 hours of wear-fighting, upkeep-cutting duty!

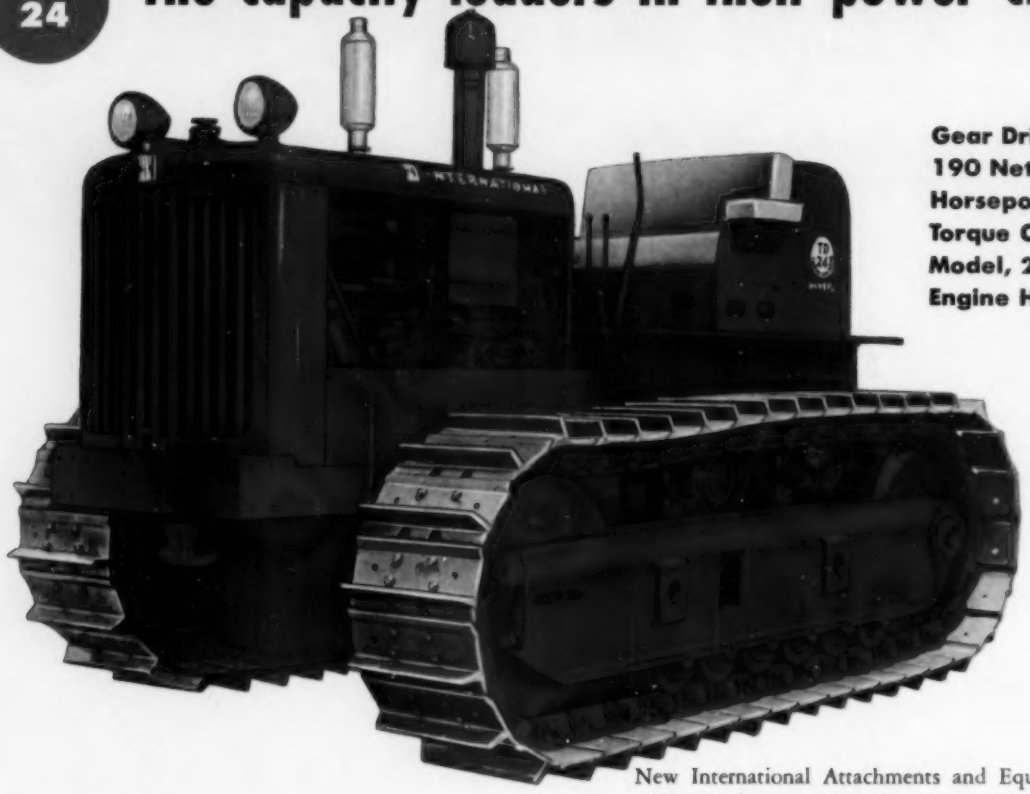
Hydraulic Power Steering Inspires Operator Cooperation! New hydraulic power steering of the TD-14 and TD-18 cuts operator fatigue—and along with the other big effort-saving advantages, makes it easier than ever to deliver full-capacity production! TD-6 and TD-9 have spring boosters to lighten the operator's job.

"Bridge-strong" track frames for "slam-bang" conditions! You are looking at the strongest track frame in the industry for crawlers of TD-18 and TD-14 size! Heavy steel box-section beams, weld-joined to heavy stress-relieved steel plates—and rigidly gusset-braced—they're your foundations for record-making "rough-and-tumble" performance!



TD 24

The capacity leaders in their power class



Gear Drive Model, 190 Net Engine Horsepower
Torque Converter Model, 200 Net Engine Horsepower

Massive—with 43,080 pounds of rock-dozing, scraper-pushing brawn (7-roller torque converter model)*—the TD-24 can give them all a lesson in operating ease, big capacity, and positive load control! Has instant high-low range and exclusive Planet Power steering to give you its tremendous *pushing*, *pulling*, and *lifting* power on any terrain—with responsiveness not available elsewhere! *Live power on both tracks, on every turn!* Backed by equipment engineered to match its strength and power!

*Gear Drive 7-roller model weighs 42,780.

New International Attachments and Equipment team with new bonus-powered crawlers to give you high-producing performance packages: 42 new Bulldozers, to fit your needs exactly . . . 4 new Drott Loaders, 1 to 3-cubic yard capacity . . . 4 new Superior® Pipe-Booms, 8 to 55-ton capacity; 3 job-proved PCU'S! . . . **Measure . . . compare . . . prove to yourself . . . new bonus-powered International crawler tractors beat anything else on tracks! Try this turnpike-paced new power for capacity, operator preference, profit potential. Ask your International Industrial Power Distributor for a bonus-powered demonstration *to your specifications!***

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by this we mean, don't make a final decision until you have considered ALL the factors — Capital Investment — Cost of Operation, namely maintenance, manpower, depreciation and FINAL COST. Many attempts have been made to generate Electric Power cheaper than by the Electric Power Company, but experience proves PURCHASED ELECTRIC POWER to be the most reliable at the lowest cost.

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Stitt "X" Type Sour Gas plugs resist corrosive action of sour gas — last months longer — require fewer changes—cut "down" time. It's not the plug price, but the "change cost" that's important! Stitts cost a little more — save hundreds of dollars per engine per year. Factory equipment in Clark, Cooper-Bessemer, Worthington, other leading engines.

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and Supply Stores Everywhere.

Construction of a modern brick and glass new home office building for The Elgen Corporation at Dallas, Texas, has begun. Completion is scheduled for July 1. The new quarters on a five-acre tract will house administrative offices, research laboratories, manufacturing area, and machine shop. Total value will be in excess of $250,000.

Schlumberger Buys Testing Firm

Schlumberger Well Surveying Corporation has purchased outright the entire assets of Johnston Testers, Inc. The sale netted $8,100,000 to Johnston Testers' stockholders, which represents a price of $13.50 per share for the 600,000 shares outstanding.

No organization changes are planned for the newly acquired company, and it will be operated under the same name — Johnston Testers, Inc.—as a wholly owned subsidiary of Schlumberger. M. O. Johnston, will remain its president.

Engineering Department Unified

In order to insure high quality of its products and to develop new production techniques, American Controls Division of Robertshaw-Fulton Controls Company has established a unified engineering department at its St. Louis, Missouri, plant.

The newly created engineering department brings under single direction all testing and quality control functions.

New Cochrane-Canadian Set-Up

Cochrane Water Conditioning, Ltd., has assumed engineering, manufacturing, and sales activities in Canada as a subsidiary of Cochrane Corporation. Through a mutually agreeable arrangement, Canadian General Electric Company, Ltd., representative of Cochrane Corporation, ceased its activities as representative December 31.

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Better PIPE TOOLS

Reversible Ratchet STOCKS and Adjustable DIES

Exceptionally convenient where space is limited, this stock simplifies pipe threading close to walls, in corners and wherever operating room is restricted. With *adjustable* dies (cut exact, over or under size threads) it is an ideal tool where valves and fittings are being installed or maintained.

"ARMSTRONG BROS." Adjustable Dies are or Special Vanadium Tool Steel, have "backed-off" teeth, correct cutting angle, ample chip clearance and correct throat angle. They start and cut easily, hold their sharpness and "spin" off pipe without jamming or tearing threads.

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"The Tool Holder People"
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...From now on, Wear Two Hats!

You, as an oilman, can wear two hats. One, of course, is doing your regular job. And the other?

Wearing that other hat simply means becoming a booster and salesman for *your* oil industry in *your* community.

Some people don't understand how vital competition is to our industry. Unfortunately, this usually leads to unfair criticism which, if unchecked, could bring government intervention and excessive regulation. None of us want that in our business!

That's why every one of us should do whatever he can to show the public how our free and fully competitive oil industry is best for everyone.

How can you help? Easily! First, take every chance you find to tell people the *truth* about any rumors or issues that concern our industry.

Second, make use of the materials supplied by the Oil Industry Information Committee. For instance, the OIIC has many informative and entertaining movies which are offered without charge. Why not arrange to have one of them shown at your local clubs or schools or anywhere you might find an audience. You'll find, as other oilmen have, that doing this not only helps you and your industry, but also gives you a great deal of personal satisfaction.

Mail this coupon today . . . and we'll let you know how you can help make sure the public knows the truth about the industry in which you make your living.

Oil Industry Information Committee
50 West 50th Street
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I'm ready to put on that second hat! Please send me information about OIIC activities in my area and how I can help.

to_____
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at_____
(your street address)

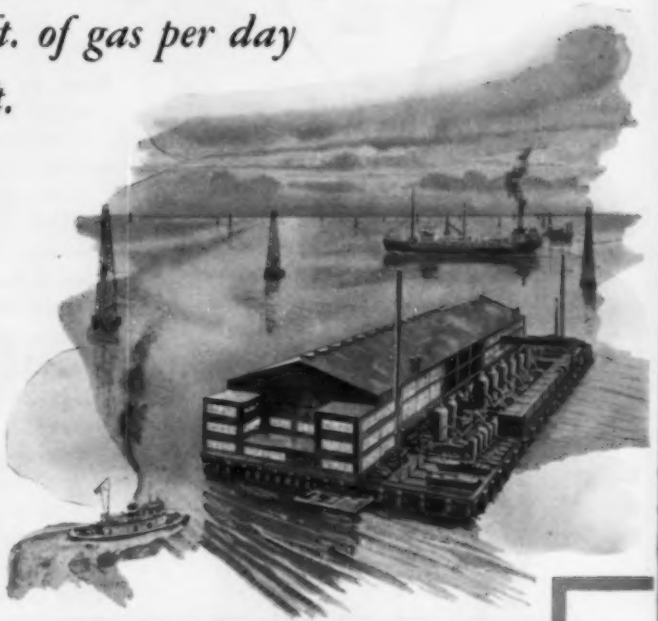
in_____
(town or city and state)

10 Ingersoll-Rand turbo-compressors now serving

Creole's outstanding offshore repressuring plant

increase oil recovery from Lake Maracaibo reservoir*

Arranged in 7 stages of compression, ten I-R Compressors are delivering 137,000,000 cu. ft. of gas per day at 2,000 psi to oil pools 4,500 ft. underneath the lake



CREOLE PETROLEUM CORPORATION's huge $20 million gas-compression plant is the largest gas conservation project so far completed in Venezuela. Located on a pile-supported platform in Lake Maracaibo, it represents a bold concept in pressure maintenance for pushing petroleum up from a reservoir 4500 feet underneath the lake.

One of the plant's innovations is the use of 10 I-R multi-stage centrifugal compressors, specially designed for this outstanding project. Arranged in 7 stages of compression, the compressors are driven by 60,000 hp of combustion-gas-turbines. Handling gas from the lake's well heads, they compress it from 10 to nearly 2000 psi—the highest operating pressure ever attained with centrifugal compressors—and then force the gas back into the ground.

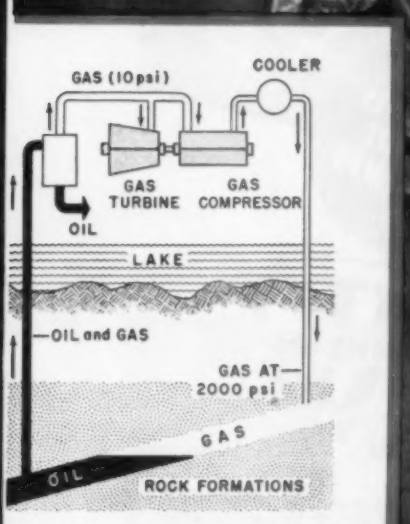
For information on these or any other Ingersoll-Rand air and gas compressors or blowers, contact your nearest I-R engineer.

*ATTESTING the efficiency, economy and dependability of I-R equipment in such continuous, heavy-duty service, 12 more I-R compressors have been ordered for still another and larger repressuring plant on Maracaibo which Creole is now constructing.

Ingersoll-Rand

12-392

11 Broadway, New York 4, N. Y.



Simplified flow diagram of Creole's huge pressure maintenance plant.

10 gas-turbine-driven Ingersoll-Rand centrifugal compressors, passing gas through 7 stages of compression from 10 to 2000 psi.

TRADE PERSONALS

William W. Sentell has been promoted to assistant sales manager of the compressor sales division, of The J. B. Beaird Company, Inc. **W. F. Raynolds** has been transferred as sales engineer from the Midland, Texas, district to the Tulsa, Oklahoma, area, formerly served by Sentell. **J. R. Sims** has joined the division as sales engineer for the Midland, Texas, district.

W. W. Sentell

W. F. Raynolds

J. R. Sims

George L. Ogdin Jr. has been appointed general sales manager of the Fulton Sylphon Division, Robertshaw-Fulton Controls Company.

W. E. Rich

A. B. Spurney

W. E. Rich has been appointed vice president of Otis Pressure Control, Inc., and Otis Engineering Corporation, already being treasurer of the two corporations.

Alan B. Spurney has been named to the newly created position of manager of foreign operations for Pacific Pumps, Inc.

E. H. Lain and **John Watson** have been named assistant eastern division sales managers in the McCullough Tool Company organization. **L. M. Oaks** has been slated as district manager, Regina district branches in Saskatchewan and Manitoba in McCullough's Canadian division.

S. W. "Sandy" Collins has been made the Alten representative in the Indiana-Illinois-Western Kentucky area for Alten Foundry & Machine Works, Inc.

Howard Cooper Johnson has been appointed assistant to the chairman of the board of United States Steel Corporation.

James D. Bailey has been appointed administrative assistant to the sales manager of Mueller Company.

Carl O. Hedner has been named assistant general sales manager of The Yale & Towne Manufacturing Company's materials handling division.

M. W. Rhoten

C. J. Ramsburg, Jr.

Myron W. Rhoten has been named managing director of Allis-Chalmers Great Britain, Ltd., the wholly owned Allis-Chalmers subsidiary with headquarters in Essendine, England. He succeeds **E. J. Mercer,** who returned in January to become general manager of the tractor group's construction machinery division.

C. J. Ramsburg Jr. has been appointed manager of tubular sales for The National Supply Company, succeeding **Edwin A. Booth,** who resigned. **W. T. Cushing Jr.** has been named manager of industrial sales, a newly created position.

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here's how!

to lick your RING PROBLEMS!

Whether it's a packing or piston ring problem — FRANCE supplies not only the product *when you need it,* but the SPECIFIC Product to lick the problem.

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Trade Personals

▸ Several personnel changes and a consolidation of national sales districts from 10 down to 7 have been announced by the Permaglas Division of A. O. Smith Corporation. Two newly created posts as assistant general sales managers will be filled by **J. Wayne Burleson** and **W. T. Halket.**

With this expansion of primary sales staff, **C. L. Hewitt Jr.** will henceforth devote full time to being manager of heating and air conditioning products without sales responsibility. In the combination of sales districts, **W. A. Dunn,** New York, becomes manager of the New England area and Metropolitan New York; **Don Shafer** is the newly appointed manager of District 73 out of Pittsburgh, Pennsylvania; **Ken O'Gorman,** former manager of District 73, moves to Chicago, Illinois, to take over District 76 in the Middle West, and **L. H. Hoelter,** who vacated that post, is the new building products manager for Permaglas, continuing to make his headquarters at Chicago. **Herman Johnson,** who formerly headed one of the combined districts at Philadelphia, now is eastern manager of Permaglas commercial water heater sales, also out of Philadelphia. **John L. Stewart** has been appointed West Coast heating and air conditioning specialist for the Permaglas Division with headquarters at Oakland, California.

▸ **Nick A. Schuster** has been appointed head of the electrical engineering department of Schlumberger Well Surveying Corporation to succeed **J. M. Bricaud.** Bricaud has returned to Paris, France, to assume the position of director of engineering for Societe Prospection de Electrique (S.P.E.) This company renders Schlumberger services in Europe.

H. C. Pitcher

Roger Northup

▸ **H. C. Pitcher** has been named general manager of Graver Construction Company, Inc., a subsidiary of Graver Tank & Manufacturing Company, Inc., with headquarters in New York City.

▸ **Roger Northup** has been appointed a new vice president of United Supply Company and will supervise the company's Texas-New Mexico operations out of Dallas, Texas.

▸ **I. J. Karassik** has been appointed assistant to the vice president and consulting engineer for Worthington Corporation's Harrison (New Jersey) division sales. **L. H. Garnar** has been named manager of the pump department and **W. P. Spinning** assistant to the manager of the steam power department. **Robert S. Sherwood** has been advanced to manager of engineering at Worthington's steam turbine division, Wellsville, New York.

▸ **O. E. "Neal" Thompson** has been made assistant sales manager of T. D. Williamson, Inc.

C. E. Trapp

I. H. Lawrence

▸ **Lloyd H. Lawrence** has been advanced from assistant sales manager to sales manager of Halliburton Oil Well Cementing Company, and **C. Eddie Trapp** from sales engineer to the new post of advertising manager.

▸ **Kenneth W. Lineberry,** president of Black, Sivalls & Bryson, Inc., has been elected president of BS&B International Corporation, the export division of Black, Sivalls & Bryson. Other new officers are **Abe Yeddis,** administrative vice president; **Hans Unger, Carlos Lavinas,** and **M. G. Purpus,** vice presidents; **Frank Ruysser,** secretary, and **Keith Davis,** treasurer.

▸ **Ralph W. Olmstead** has been elected a director of the The H. K. Ferguson Company and its subsidiaries.

▸ **Leonard Botts,** former production equipment specialist at Wichita Falls, Texas, is being transferred to Continental Supply Company's Maracaibo, Venezuela, outlet. **Morris S. Caraway** will replace Botts. **Dwight W. Mayes** is the new store manager for Continental at the Virden, Manitoba, Canada, store. He is replacing **J. B. Eyndhoven,** who will become store manager for Estevan, Saskatchewan.

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That's what drillers and profit-wise operators everywhere are saying. They're using the Improved THOMPSON Vibrating Shale Separator with Sample Machine. It's an important part of their standard equipment.

Wells are fed a steady flow of *clean mud* with a THOMPSON because its vibrating action effectively removes abrasives and shale from drilling muds. The Sample Machine supplies foot-by-foot specimens of formation cuttings. It's standard on all THOMPSON Separators unless otherwise specified.

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...the Direct-Drive CHAIN SAW with ALL of the features YOU want

Only 19 pounds

Full 5 Horsepower

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Faster Cutting Speeds

AND WITH THE NEW HOMELITE FLOATING POWER, you'll find handling ease you never knew before. The all-angle, any-position carburetor gives you full power cutting — whether you're felling, bucking, notching, limbing or under-cutting.

Floating Power lets you cut with less effort, less fatigue than any other chain saw. Because the Homelite EZ weighs only 19 pounds you can carry it anywhere. Its full 5 horsepower cuts through 8″ Oak in 5 seconds and 18″ Pine in 14 seconds. And the three bar sizes — 17″, 21″ and 25″ will handle trees up to 3 feet in diameter.

The EZ brings you Homelite dependability at a new low cost — not just a low initial cost, but also lower maintenance and operating costs than any other direct-drive chain saw.

See this new floating power now! Try it and you'll know why the Homelite EZ offers easier cutting, faster cutting, more profitable cutting for your dollar.

Ask your Homelite dealer for a free demonstration. Also ask about the convenient time payment plan.

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24 Homelite EZ chain saws being given away each month. Nothing to buy. Nothing to write. No obligation. Just ask your dealer how you can win. See him today!

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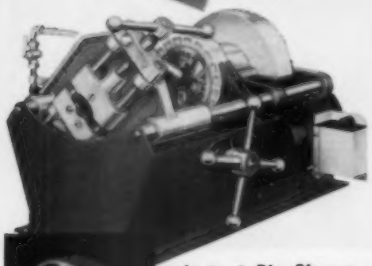

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Spin Torque Chucking
High Speed Threading

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BUILDERS OF THE WORLD'S FINEST PIPE TOOLS

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A. J. Broggini has been elected executive vice president and chairman of the executive committee of the Badger Manufacturing Company. He has been a member of the board of directors and of the executive committee since 1955. Broggini is a chemical engineering graduate of the University of Michigan.

A. J. Broggini

W. T. Carpenter of Dallas, Texas and **Z. M. Barnett** of Shreveport, Louisiana, have formed Well Service Engineers, C.A., a new company to provide highly mobile well servicing in Eastern Venezuela. Both men are petroleum engineers and have had years of service with Venezuelan Atlantic Oil Company in the Oritupano district. Headquarters for the new company is at Santa Barbara in the state of Managas, Venezuela.

George K. Turner has become chief electronics engineer for Spinco Division, Beckman Instruments, Inc.

DEATHS

Dennis F. McCarthy, 67, former vice president and general manager of the A. O. Smith Corporation at Houston, Texas, and former manager of A. O. Smith's tubular products division at Milwaukee, Wisconsin, died in Milwaukee February 5 after a long illness. McCarthy became associated with A. O. Smith in 1936 and served on the president's staff for 10 years.

W. M. Reed, 63, founder and chairman of the board of the American Air Filter Company, Inc., died at his winter home in Ft. Lauderdale, Florida, February 2 from a heart attack. In 1922, he founded the Reed Air Filter Company, parent organization of American Air Filter Company.

Two retired sales executives of The Youngstown Sheet and Tube Company died recently. They were: **George F. Holly Sr.,** 73, former manager of conduit sales, who died January 31, and **Edwin P. "Ed" Corey,** 79, former general manager of tubular sales, who died January 29. Holly retired from Sheet and Tube in 1953 after 42 years of service. Corey, with a steel career of 52 years, retired nearly 9 years ago.

Harvey Hewitt, retired Bethlehem Steel Corporation executive, died at his home in Pasadena, California, January 28. At the time of his retirement two years ago, he was vice president in charge of all West Coast sales operations.

H. A. Flannery, 61, manager of engineering for the Goodyear Tire & Rubber Company since 1935, died January 28, as a result of a heart attack. He was educated at Cornell University.

Charles E. Ashcraft, 44, sales engineer and partner with the Mann Engineering Company, Pittsburgh, Pennsylvania, died December 18. Ashcraft joined the Mann organization in 1946. He attended the University of Cincinnati.

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Carryable
Construction
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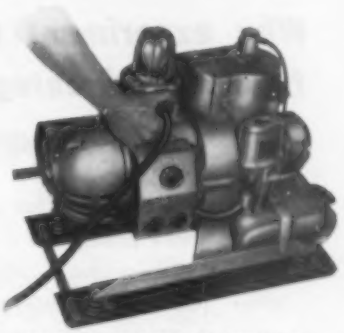
SELF-PRIMING CENTRIFUGAL AND DIAPHRAGM PUMPS
Sizes: 1½" to 3" — capacities to 15,000 g.p.h. for dewatering and water supply.



ELECTRIC GENERATOR SETS FOR TOOLS AND LIGHTS
Complete range of sizes and voltages up to 5,000 watts.

LIGHTWEIGHT POWERFUL ONE-MAN CHAIN SAWS;
Complete line of saws with clearing and brushcutter attachments for every woodcutting job.

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A DIVISION OF TEXTRON AMERICAN, INC.
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TEMPERATURE EXTREMES — Hundreds of Stewart & Stevenson Diesel-powered generator sets are operating inside the Arctic Circle where temperatures drop below —70° F. and in the South Pacific where temperatures exceed + 120° F.

SEVERE DUST — Stewart & Stevenson-supplied drilling engines and pumping engines have been operating successfully for years not only in some of the worst parts of the "Dust Bowl" but also in Desert Regions of the Middle East.

What is your

Why experiment with unfamiliar power problems – when you can take full advantage of the experience and know-how of the Nation's Largest Distributor of Diesel Engines?

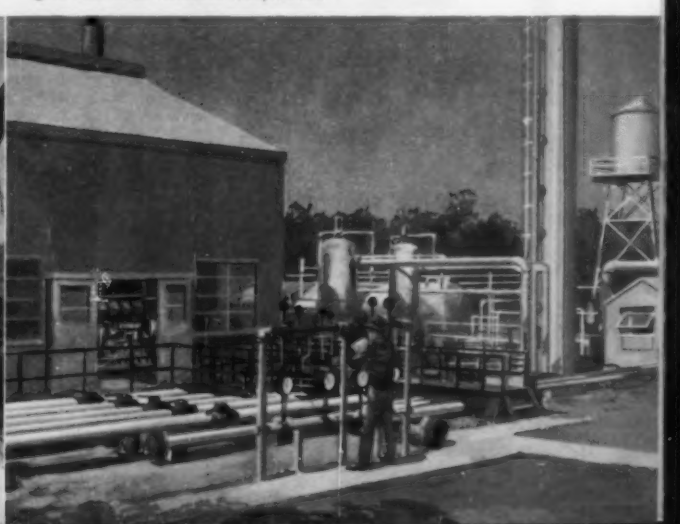
The correct selection of an engine or generator set can be a tricky problem if it is not based on sound and practical experience rather than theory.

When you face an application problem, don't experiment when you can be sure! Besides the advantages of practical application knowledge, Stewart & Stevenson equipment usually costs far less in the final analysis than most other equipment.

You don't take chances when you deal with Stewart & Stevenson. There is **one** source and **one** responsibility for all your power requirements. Call us and let our experience keep you out of trouble.

CRAMPED QUARTERS — Stewart & Stevenson engineers have frequently found ways to install more powerful engines in cramped engine rooms as well as other applications where space conservation is of prime importance. This Stewart & Stevenson "Vertical" application of the General Motors Diesel is a typical example of how Stewart & Stevenson ingenuity saved space, increased efficiency and in addition actually cost less to buy.

EXPLOSION HAZARDS — Successful Stewart & Stevenson engine installations have been made in hazardous areas around refineries and gas processing plants. Stewart & Stevenson engineers are thoroughly familiar with explosion and vapor-proofing in the design of switchgear and other electrical components.



MARINE PROBLEMS — For years, Stewart & Stevenson has been dealing with the corrosive and troublesome aspects of sea water, supplying engines and generator sets for offshore service boats, fishing boats, tugs, and other craft working in the waters of the Gulf Coast.

HIGH ALTITUDES — Stewart & Stevenson drilling engines and generator sets are operating successfully at altitudes in excess of 12,000 feet in the Rocky Mountain Area as well as other remote locations throughout the world.

power problem?

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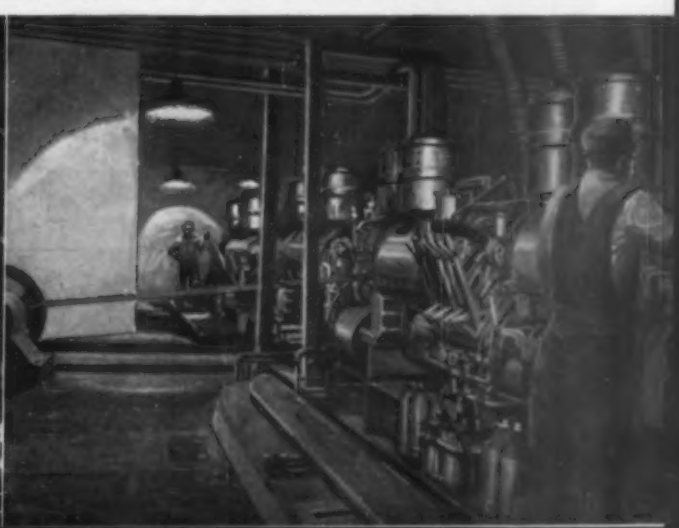
THE NATION'S LARGEST DISTRIBUTORS OF GM DIESEL ENGINES

ELECTRICAL DESIGN — Stewart & Stevenson has sold more Diesel generator sets in more different types of applications than any other distributor of Diesel engines in the nation. Units are operating in temperatures that range from — 70° F. to + 130° F. and at altitudes that range up to 12,000 feet.

FUEL SELECTION — Complicated fuel conditions are no problem to Stewart & Stevenson engineers. The line of engines offered by Stewart & Stevenson cover all types of fuels such as butane, natural gas or diesel fuel and Stewart & Stevenson's experience in burning inferior types of fuels such as heavy crudes has been extensive.



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TEMPERATURE RECORDING...

Newly designed, Model "1000" Auto-Lite Recorder gives permanent proof of temperature behavior. • 6" clear reading chart; various standard ranges from minus 40°F. to plus 550°F. • 3 standard types; choice of 24-hr. or 7-day cycle. • Electric or mechanical chart drive. • With capillary tubing for remote reading. Priced from $49.50.

Send for new catalog describing many styles of Auto-Lite temperature Recorders and Indicators.

Model "1000"

THE ELECTRIC AUTO-LITE COMPANY
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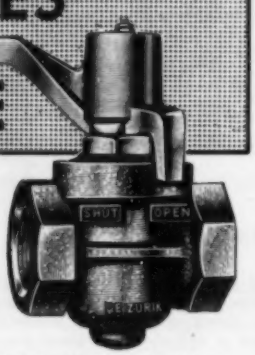
TEMPERATURE RECORDERS

DeZURIK VALVES STOP LEAKAGE



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On bleeder lines from pumping wells, on water treater tanks, on rotary drilling mud, on crude oil tank battery lines, on suction to high pressure oil well cementing pump trucks, on vacuum trucks . . . on these and many other petroleum applications, DeZurik Valves are demonstrating a remarkable ability to stop leakage without constant maintenance. On liquid flow or vacuum . . . you'll find DeZurik Easy-Operating Plug Valves will do a superior job!

Manufactured in a full range of sizes, materials and models

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PETROLEUM ENGINEERS

Experienced graduate engineers for immediate openings in Saudi Arabia and New York City. For engineering work in development, production, drilling, process, and oil and gas engineering on primary and secondary recovery problems.

RESERVOIR FLUID ANALYST

With degree in Physical Chemistry or Chemical Engineering plus 5 years' petroleum production engineering which should include 2 years' study of reservoir fluid behavior.

Salaries commensurate with training and experience. Write outlining personal history and work experience. Please include telephone number.

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EMULSION PLANT SUPERVISOR. Venturing into asphalt emulsions and have opening for man thoroughly experienced in this field. Preferably under 35 years of age. Location Tuscaloosa, Alabama. Submit complete resume of background and experience. **Hunt Oil Company,** P. O. Box 3053, Dallas.

ADVERTISING SALES

Trainee for leading oil and gas publication. Must be personable, intelligent, tactfully aggressive. He could be a petroleum, mechanical or chemical engineer presently employed in the oil-gas industry, or a graduate in advertising-marketing; writing aptitude helpful; but this specific background not required. Sales experience valuable, but not a must. Opportunity to grow into five figure income in two years. **Write Box 1589, Dallas.**

Applications are invited for the post of Professor of Petroleum Engineering (Prospecting and Production) at the **Faculty of Engineering, Cairo University, Egypt.**

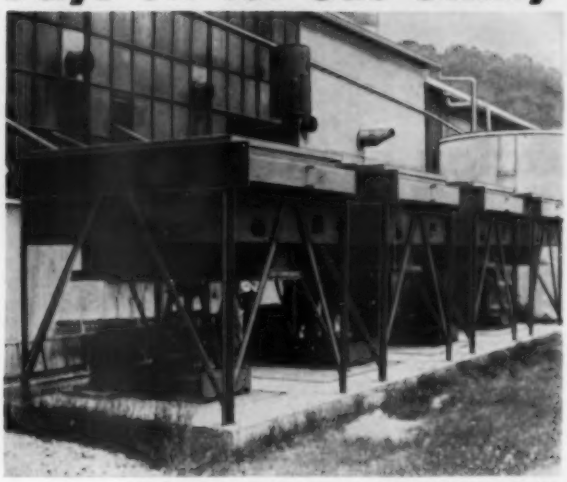
Candidates must possess a Ph.D. degree in Petroleum Engineering and should be capable of delivering lectures in English.

Appointment shall be by contract for two calendar years, renewable thereafter for five years if desired. Salary: 900 to 1500 Egyptian pounds, basic, plus 360 Egyptian pounds expatriation allowance and 75 Egyptian pounds cost of living allowance per annum. (The Egyptian pound represents $2.87.) Higher basic salaries may be considered in cases of outstanding qualifications.

Full particulars as to age, academic qualifications, engineering and teaching experience, recent scientific and engineering contributions and publications should reach the Dean of the Faculty by registered mail before March 1, 1956.

Young Engineering Talent

Pays off for Gas Utility*

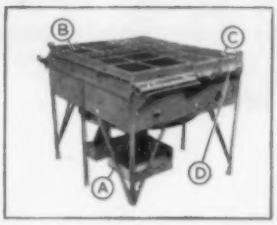


*South Penn Natural Gas Co. Station, Smithfield, West Va.

Young "HC" Atmospheric Radiators

eliminate cooling water supply problems

The Problem: To replace an old cooling tower serving gas compressors. A nearby creek furnished the uncertain water supply.



Young HC Horizontal Core Cooler and Condenser

How Young solved it

Four Young Radiator Company HC Atmospheric Radiators were specified to cool four 165-hp compressor engines. Natural gas is compressed from local field lines and well-head to pressures suitable for shipping to distant sales points. Installation of the Young Units has modernized the compressor cooling system. In addition it has made the utility independent of the uncertain water supply.

A. Independent mounted fans eliminate unit vibration.
B. Coils designed for easy access to tube ends.
C. Coils supplied for any operating pressure.
D. Steel tanks treated for corrosion resistance.

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Put Young Talent to work for you . . .

Solving heat transfer problems is what we do best because it is our very reason for being. You, too, can harness the power of Young engineering talent. Write, wire or call without obligation.

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Creative HEAT TRANSFER ENGINEERS FOR INDUSTRY
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is the word for these efficient little RIDGID Drop-Head Dies!

Easy threading of ⅛" to 2" pipe or conduit

Snap size head you want into ratchet drive ring, from either side—it can't fall out. Dies reverse easily for close-to-wall threading. 00R and 0R, ⅛" to 1"; 111R and 11R, ⅛" to 1¼"; 12R, ⅛" to 2". Free carrier with sets. Conduit and special dies available. Real work-savers—at your Supply House!

RIDGID Bolt Threaders, too—No. 00R-B, ¼" to 1", National coarse and fine thread, efficient drop-head dies.

"Threaded Pipe—It's Tight—It's Best—Costs Less"

RIDGID Work-Saver Pipe Tools

The Ridge Tool Company, Elyria, Ohio, U. S. A.

New cost-cutting TRICKLE FLOW process uses low hydrogen recycle to get 99.5% desulfurization of gas oil

With 80% hydrogen purity, the new SHELL TRICKLE FLOW process yields doctor-sweet product at lower cost.

TRICKLE FLOW operation offers you these five additional advantages:

1. **Smaller, simpler, easier-to-maintain plant**
2. **No need to rerun product**
3. **High liquid yields**
4. **Sustained catalyst activity**
5. **Uses a rugged, low-cost catalyst**

Flexible TRICKLE FLOW process has been refinery-proved, and now is successfully turning out a premium product in the modern Canadian Petrofina Refinery. This unit was engineered by the Lummus Company.

We'll be glad to supply further information about this efficient, low-cost desulfurization process. Address your inquiry to:

SHELL DEVELOPMENT COMPANY
50 West 50th Street, New York 20, New York

SHELL

"I've solved my drill pipe problems!"

How? Simple—I buy Youngstown Drill Pipe. My Youngstown distributor can furnish Drill Pipe with upsets or threads for all types of tool joints. He can supply my requirements in a hurry, wherever I need it.

I save time and money, and get the best value for my dollar.

Do you have Drill Pipe problems? Contact your nearest Youngstown distributor.

Buy from one source-Buy Youngstown.

QUALITY YOUNGSTOWN SERVICE

YOUNGSTOWN
DRILL PIPE
...MADE FOR OIL MEN
BY PIPE MEN

Youngstown
DRILL PIPE

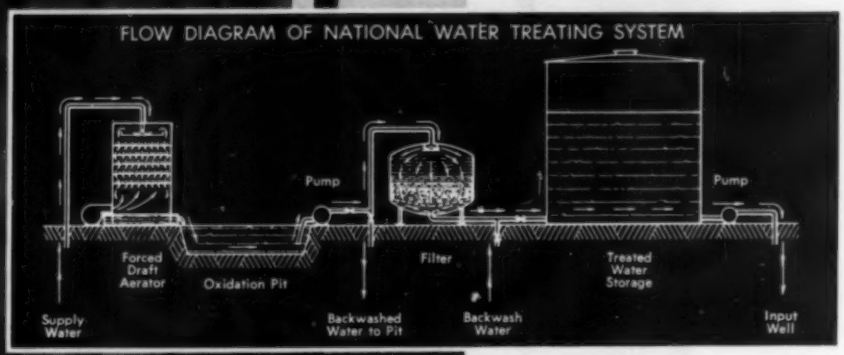
THE YOUNGSTOWN SHEET AND TUBE COMPANY *Manufacturers of Carbon, Alloy and Yoloy Steel*

General Offices Youngstown, Ohio District Sales Offices in Principal Cities.

SHEETS - STRIP - PLATES - STANDARD PIPE - LINE PIPE - OIL COUNTRY TUBULAR GOODS - CONDUIT AND EMT - MECHANICAL TUBING - COLD FINISHED BARS - HOT ROLLED BARS - WIRE - HOT ROLLED RODS - COKE TIN PLATE - ELECTROLYTIC TIN PLATE - BLACK PLATE - RAILROAD TRACK SPIKES - MINE ROOF BOLTS

AERATION!

National Aerator for treating supply water or disposal water in open water system.



Two National Aerators in series with water supply well located north of Tulsa, Oklahoma.

A Part of The . . .

NATIONAL "OPEN SYSTEM"

Salt Water Treating

The National forced draft Aerator is fabricated of redwood with reinforced fiber glass distributor and splash trays, to facilitate ease of and reduce frequency of cleaning. Distribution of water from tray to tray assures liberation of water-bound gases which are expelled to the atmosphere by controlling the volume of air introduced at bottom of the Aerator.

Submerged Aerators are also manufactured by National as are complete closed and open water systems.

Our Engineering Department welcomes inquiries concerning your water disposal problems.

It's a National®

NATIONAL TANK COMPANY

TULSA, OKLAHOMA

THE *Petroleum* ENGINEER

Exploration
Drilling
Producing

HURT OIL CO., LTD.

SAN JACINTO BUILDING
HOUSTON 2

November 4, 1955

Good work, Mgen. This is the kind of Service that has put O-C-T on top!
JM.

Mr. John Maher, President
Oil Center Tool Company
Post Office Box 3091
Houston 1, Texas

Dear John:

The assistance which your organization rendered us was a tremendous contribution in solving our problems on the Kaplan well fire.

While watching Kinley's fire fighting crew at work on Wednesday, I was especially impressed with the skill and experience of Mr. Richards and Mr. White of your organization, who were down in the pit with Kinley and his crew. They certainly know their business, and were a wonderful asset.

Also, the transportation you provided with the Twin Engine Aero Commander worked out just right, and I want to tell you how very favorably impressed I was with your fine Pilot. He couldn't have been more considerate and cooperative.

My sincere appreciation and thanks for your help.

Sincerely yours,

Harry Hurt

HH:mh

(Advertisement)

look for this → symbol

...it identifies all Dresser Companies and their products

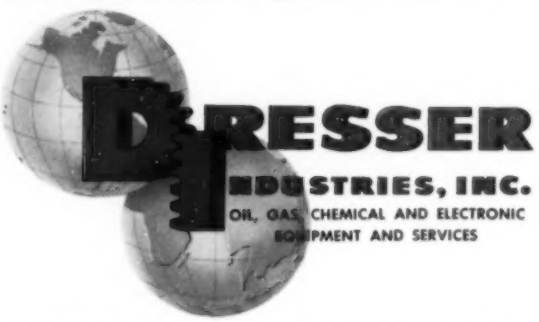
CLARK BROS. CO. compressors	DRESSER-IDECO DIVISION steel towers	DRESSER MANUFACTURING DIVISION couplings	IDECO drilling rigs	LANE-WELLS COMPANY technical oilfield services
MAGNET COVE BARIUM CORP. drilling mud	PACIFIC PUMPS, INC. pumps	ROOTS-CONNERSVILLE BLOWER DIVISION blowers	SECURITY ENGINEERING DIVISION drilling bits	SOUTHWESTERN INDUSTRIAL ELECTRONICS electronic instrumentation

...it is your guarantee of the DRESSER *plus*+

You gain an important extra plus value every time you are served by any of the Dresser companies. This is the unique way Dresser operates to serve you better. Each Dresser company works independently to assure maximum individual attention to your specific needs . . . yet all are teamed together in a single organization to provide a group of research, engineering, and manufacturing services. From Dresser you obtain equipment based on the over-all experience of many companies in many industries.

As performance demands on equipment become increasingly greater, Dresser will continue the technological changes in your field. You can count on the Dresser companies as major suppliers of equipment researched and developed to serve you better and meet your future needs.

Wherever you are, whatever your needs, specify equipment from Dresser companies. No other single organization offers you the same broad range of "know-how" coupled with individual company attention to these specific needs. Be sure to look for the symbol that identifies the Dresser companies. It's your guarantee of the Dresser *Plus* + . . . the mark of superior equipment and services which have become the standard of comparison the world over.



REPUBLIC NATIONAL BANK BUILDING • POST OFFICE BOX 718 • DALLAS 21, TEXAS

Tomorrow's Progress Planned Today

Of Things To Come . . . In Oil

LOOK TO FURTHER AWAKENING by all segments of the industry to get its story across fully and effectively all down the line to the people most affected by federal and local legislation. This new awakening was brought about by veto of the Harris-Fulbright natural gas bill, and pressure brought by state and federal bodies for more oil and gas regulation.

INDUSTRY HEADED FOR HIGH ACTIVITY, after a slow start in January and February. Stimulus is increased petroleum demand. Bureau of Mines estimated total demand for domestic crude in March would average 7,010,000 bbl daily. Demand for March, 1955, was 6,667,700 bbl daily. Imports will rise, too. February imports increased 3 per cent over same period 1955.

TEXACO'S SIGNIFICANT DISCOVERY will set off activity in Paradox Basin in southeastern Utah. Wildcat flowed 430 bbl on 8-hour test from basal Hermosa at 5828-74 ft. New strike is 10½ miles north of Shell's 1954 discovery at Desert Creek that flowed over 1000 bbl per day on test.

NO NEW GAS BILL for current session of Congress, even though President is in favor of basic principals involved. Election-year promises, influence-buying smear will squelch hopes for presenting the issue this year. Next year is best bet, but it will take FPC that long to iron out difficulties imposed by H-F veto, and set up machinery to handle newly-imposed authority.

TURBODRILL RESEARCH and development in the U. S. to get a second try with Dresser negotiations for Russian unit purported superior to American trial models. Before the drill can get a test in this country, manufacturers must first clear government hurdles. Standard of California and A. O. Smith gave up joint development effort on a turbodrill which failed to compete with slimhole, air and gas drilling, aerated muds and improved jet bits.

AUTOMATIC LEASE PROGRAMMING . . . to see wider use in '56. Many new systems developed last year now proved, new ideas being put to work on wide scale. Even automatic custody transfer of crude from producer to pipe line company now being accepted by some. Big reason for more auto control installations is larger number of wells, lower costs, to increase efficiency of manpower and equipment.

SCHLUMBERGER
SCHLUMBERGER
JOHNSTON
TESTERS

A star hitched to a star

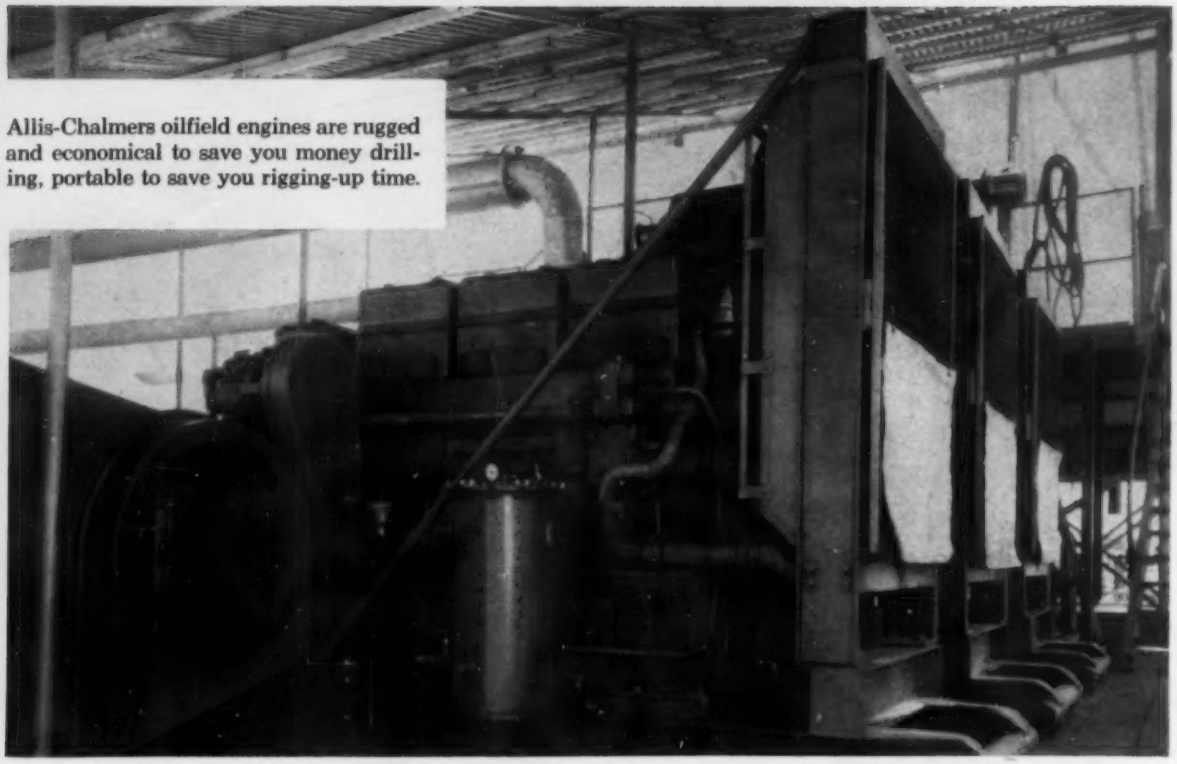
JOHNSTON TESTERS IS NOW A SUBSIDIARY OF SCHLUMBERGER

Our goal at Johnston Testers has always been to bring the best possible service to our customers. Now, to continue meeting the demands of the expanding oil industry, to continue bringing the best formation testing equipment and know-how to the industry, we have become a part of Schlumberger. Immediately, we share, and you share with us, in the excellent research facilities of Schlumberger and a stronger Johnston Testers service organization. With this greater strength, Johnston Testers will continue to grow and serve the oil industry better.

JOHNSTON TESTERS

first in drill **stem testing**

a stronger service organization for you



Allis-Chalmers oilfield engines are rugged and economical to save you money drilling, portable to save you rigging-up time.

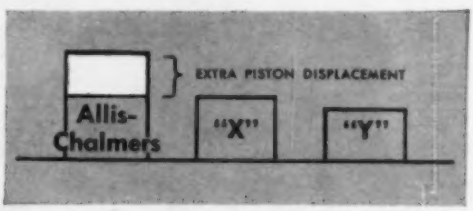
Allis-Chalmers Oilfield Engines are built to give you more . . . *and they do!*

Whether you need but a few horsepower or several hundred; whether you choose diesel, gasoline, natural gas, butane or propane fuel — you can expect to find an Allis-Chalmers engine to best fit your requirements.

But you can expect more — more usable horsepower, with conservative ratings, high average torque — more time on the job because of rugged construction, ease of servicing — more economical operation, with maximum fuel economy, long service life.

Behind these performance and satisfaction "extras" are many design and construction advantages. For instance, there is longer engine life, less maintenance in the Allis-Chalmers strong, rigid, one-piece block.

Many other features also contribute to long engine life, low maintenance costs — extra-strong, forged crankshafts, big rod-bearing area, oversize piston pins, five-ring pistons for best sealing.



There is also great reserve power in Allis-Chalmers big piston displacement. This means higher usable torque in the normal operating range, lighter engine loading, less strain on the engine.

Let your Buda Division, Allis-Chalmers distributor give you the complete story on these economical, dependable engines to fill every power need.

ALLIS-CHALMERS, BUDA DIVISION, MILWAUKEE 1, WISCONSIN

ALLIS-CHALMERS A-C

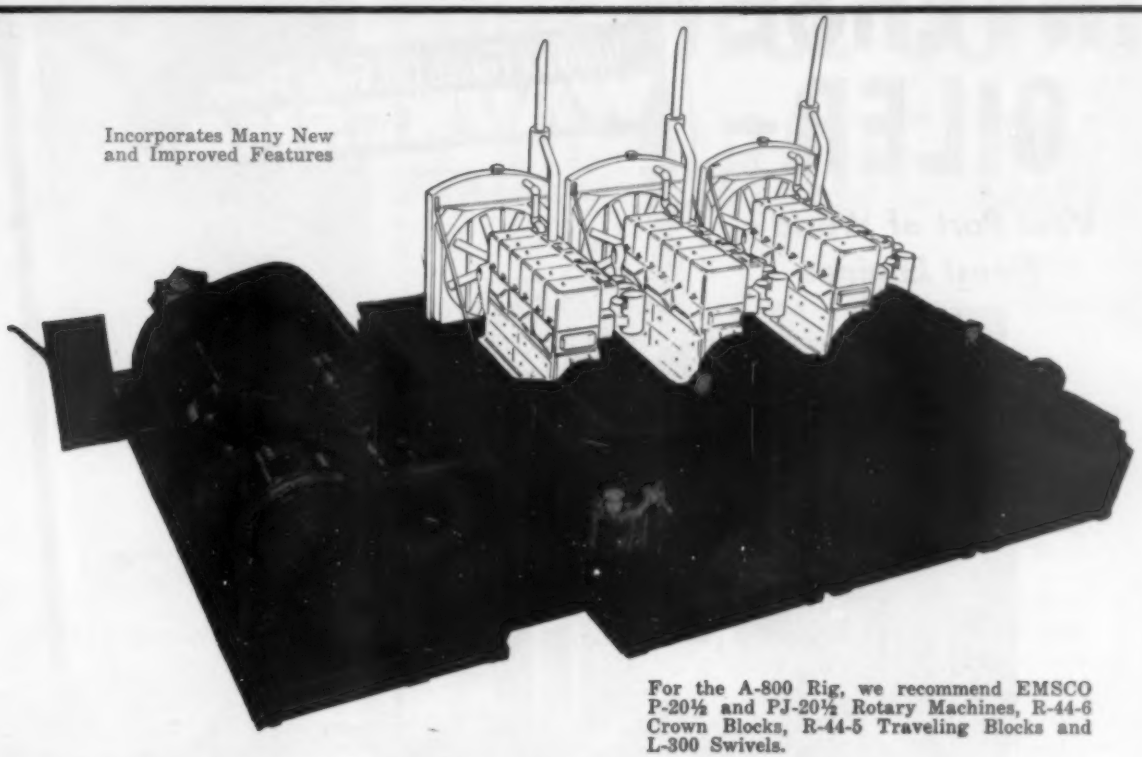
BO-1

Complete "Packaged Portability" with

THE AMAZING NEW EMSCO A-800 RIG

designed to slash operating costs

Incorporates Many New and Improved Features



For the A-800 Rig, we recommend EMSCO P-20½ and PJ-20½ Rotary Machines, R-44-6 Crown Blocks, R-44-5 Traveling Blocks and L-300 Swivels.

OUTSTANDING ADVANTAGES

1. Designed especially to reduce operating costs on medium to deep wells.
2. Ships easily on 4 trucks in 4 convenient "packages."
3. Can be powered by any three drilling engines having a total power output of 1,000 h.p. Engine to transmission drives may be Fawick clutch, torque converter or hydraulic coupling.
4. Drum is 24" in diameter and 50" long.
5. Selective transmission is in No. 1 engine package. Output shaft of the sectional type compound and input shaft of the selective are one and the same.
6. Greatly improved and simplified brake cooling system.
7. New friction-compounding clutch saves operator time.
8. Highly effective lubrication system.

Another Major EMSCO Help for the Drilling Contractor

Effectively sealed from entry of mud or other foreign material, EMSCO P Rotary Machines are superior in design and construction and built for long life and quiet performance.

Learn more about the new EMSCO A-800 Rig and EMSCO P Rotary Machines. Call CONTINENTAL today for complete information.

CONTINENTAL

Serving the Oil and Gas Industries

CONTINENTAL SUPPLY COMPANY

A Division of The Youngstown Sheet and Tube Company

General Offices: Dallas, Texas

Representatives in all principal oil fields of the world

R-602

EMSCO

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EMSCO MANUFACTURING COMPANY

Garland, Tex. • LOS ANGELES, CALIF. • Houston, Tex.

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Still on the job after 9 years with

MARVEL INVERSE OILER—

Vital Part of World's Finest Engines

The Marvel Inverse Oiler ⟶

is an integral part of the Waukesha NKRU gas unit. Operating off the intake manifold, this completely automatic Oiler feeds Marvel Mystery Oil exactly in proportion to engine loads . . . gives direct protection to the all-important upper cylinder areas.

STILL ON THE JOB after *nine years'* service! This dependable Waukesha NK Series engine, pictured above, has *never* had the head or pan off in all this time.

Like most fine performers, the Waukesha engine is equipped with a Marvel Inverse Oiler for Marvel Mystery Oil—finest performing lubricant on the market.

For engine manufacturers have found that engines equipped with Marvel Inverse Oilers, can be depended upon to give quick acceleration to save trip time . . . keep operating costs to a minimum . . . guarantee hours of continuous performance . . . keep "down time" low by extending periods between overhauls.

The Marvel Inverse Oiler, incorporated as a vital unit in the engine's lubrication system, feeds Marvel Mystery Oil in exact proportion to engine speed and load . . . properly lubricating valves and guides, preventing wear and sticking. It keeps upper piston rings free in their grooves . . . retards ring flutter . . . and cushions ring pounding which can result in ring breakages.

Of course, it is actually the oil that performs these functions and only Marvel Mystery Oil is blended for this purpose and for the Marvel Inverse Oiler!

See Your Local Jobber or Oil Well Supply House

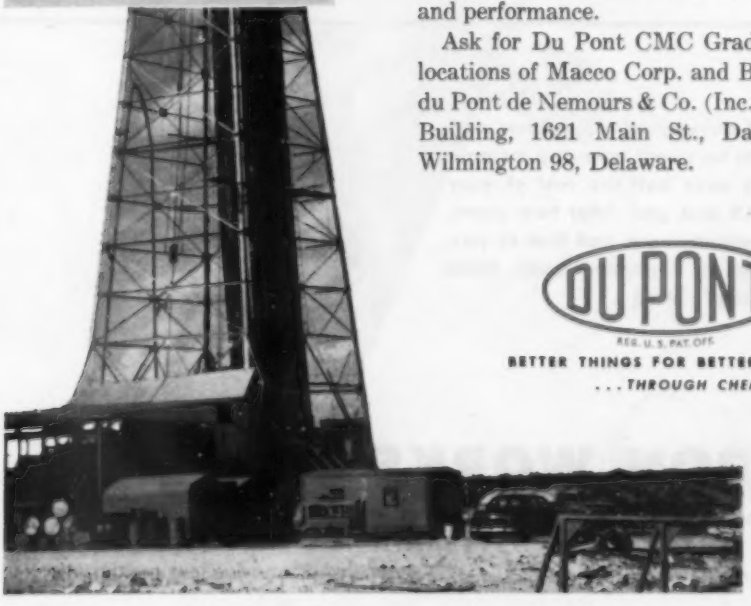
EMEROL MFG. CO., Inc.

Dept. 428, 4242 West 69th Street New York 23, N. Y.

First field report:

MUD COSTS CUT $4,650 IN 17,500-FOOT WELL USING DU PONT CMC GRADE DM

MORE EFFICIENT FRESH-WATER MUD SYSTEMS are obtained by addition of Du Pont CMC. It keeps fluid loss low . . . reduces mud viscosity . . . resists degradation effects of high temperatures and bacteria . . . improves oil-water emulsions . . . has excellent wall-building properties.



Du Pont CMC minimizes fluid loss with low mud viscosity at much lower cost than refined CMC

One major oil company added Du Pont CMC to a fresh-water mud in one of three 17,500-foot wells in the same Gulf Coast field, and refined CMC to the other two. Mud costs at the well using Du Pont CMC were $4,650 and $4,250 lower, respectively, than costs at the other two wells. Mud viscosity was lower at the Grade DM well, with fluid loss about the same for all three wells.

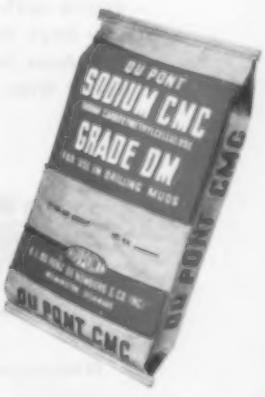
Cost savings like these, along with excellent fluid-loss control and low mud viscosity, are also reported from offshore wells. Versatile Du Pont CMC thins out sea-water mud systems . . . avoids the high mud viscosities often caused by starch in lime-treated muds. It resists thermal and bacterial degradation and can be used in high-temperature wells. Join the growing number of companies using Du Pont CMC Grade DM—you'll benefit from its economy and performance.

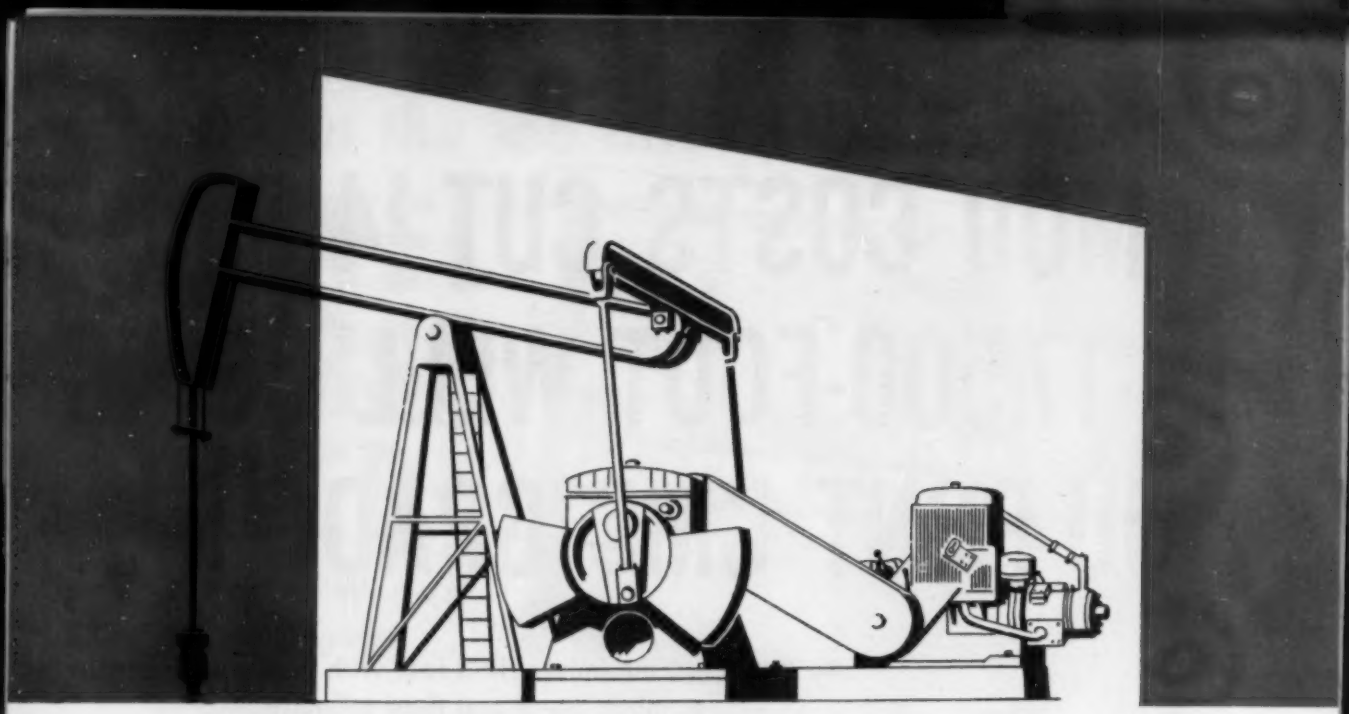
Ask for Du Pont CMC Grade DM from your mud dealer, or locations of Macco Corp. and Barada & Page, Inc., or from E. I. du Pont de Nemours & Co. (Inc.), Explosives Department, Wilson Building, 1621 Main St., Dallas, Texas, or Chemical Sales, Wilmington 98, Delaware.

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY





HOW TO LOWER PRODUCTION COSTS:

Power your pumper

WITH *Ajax and Gas*

The fog of questions about rising production costs and narrowing profit margins can be swept away by a single sunlit fact: you can usually save half the cost of your engine each year with AJAX and gas! After two years, you have only negligible maintenance and fuel to pay for—from then on out, years of continued profit. More facts? Write us—see your Supply Man!

AJAX

Ajax IRON WORKS

Builders of GAS AND OIL ENGINES, PRESSURE PUMPS, STEAM DRILLING ENGINES, INDUSTRIAL STEAM ENGINES

CORRY, PENNSYLVANIA

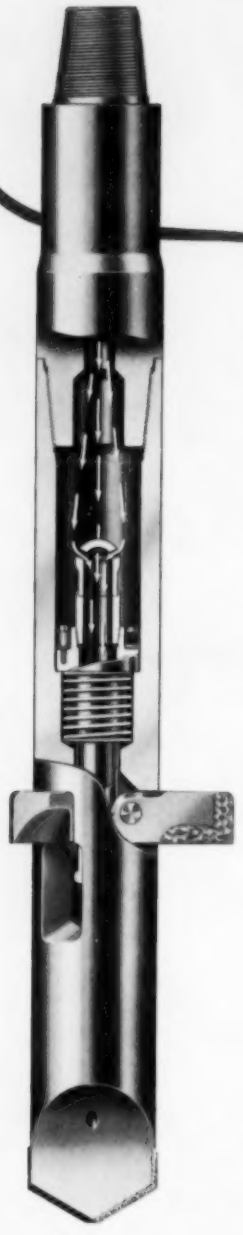
Oil Field Distributors: THE NATIONAL SUPPLY CO., PITTSBURGH, PA. • R. B. MOORE SUPPLY CO., BOLIVAR, N. Y. • BETHLEHEM SUPPLY CO., TULSA, OKLAHOMA

GRANT
OIL TOOL COMPANY

No. 2 of a series on how Grant specializes in one job: Building the Tools that help you drill wells better!

It puts the finishing touch on the wall of your well!

Grant 3-Blade Wall Scraper



Model 1540 Wall Scraper

Every operator knows that *drilled* hole is not always *finished* hole.

WHATEVER THE NEED, enlarging and scraping in the capable hands of a Grant 3-Blade Wall Scraper will put the finishing touches on drilled hole for easier, safer and faster completion and work-over operations!

Take one minute to check the features that make the Grant outstanding for *all* your wall scraping operations—

THREE-BLADE WALL CONTACT makes the Grant smooth-running, prevents torque loads on the string, goes easy on surface equipment even while cutting the toughest formation and biggest diameters.

BLADE OPENING AND CLOSING are under complete operator control by simply regulating pump pressure. Blades open uniformly *as a unit*, cut to full gauge without dependence upon pump pressure.

ADEQUATE FLUID VOLUME for quick removal of cuttings is assured because the Grant carries full circulation to bottom. No fluid by-pass is required.

EXTRA THICK AND HEAVY BLADES are faced with tungsten carbide and hard facing alloy for extra hours of scraping. Blades and blade recesses are non-clogging, require no circulation for cleaning.

Driftblade Stabilizer | Underreamer | Cushion Stabilizer | Casing Scraper | Model 6480-A Reamer Near Bit Type

Grant stocks and services a complete size range of Wall Scrapers to meet every scraping need from stovepipe hole to bottom! *For the complete story on Grant Scrapers, simply write for Bulletin No. 60, or ask for the complete Grant Catalog on all Grant Tools. There's a Grant service man in your area who will gladly supply details!*

GRANT

OIL TOOL COMPANY

Main Office and Plant: 2042 East Vernon Avenue, Los Angeles 58, California

CALIFORNIA—Ventura—Phone Miller 3-6767
Bakersfield—Phone FAirview 5-0907
Compton—Phone Newcastle 5-0441
TEXAS—Odessa—Phone 6-4852
Houston—Phone Mohawk 4-0631
OKLAHOMA—Oklahoma City—Phone Melrose 7-3251
LOUISIANA—Lafayette—Phone 8-7641
Harvey—Phone 1-3592
NEW MEXICO—Hobbs—Phone 3-4211
CANADA—Edmonton—Phone 29-7233
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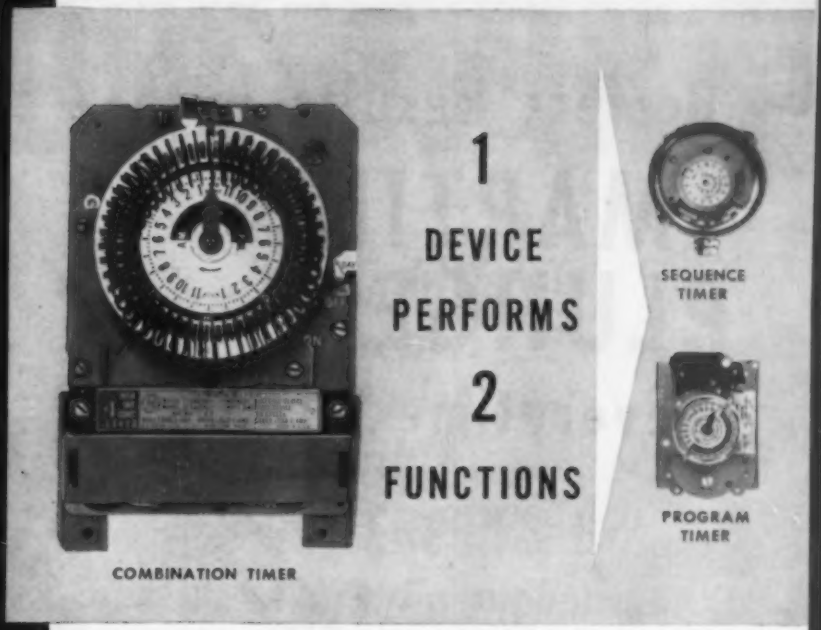


NEW COMBINATION TIMER performs functions of program timing, and automatic sequence restart. It is now part of every G-E oil-well pumping starter.

NEW

Timer Now Standard on All G-E Oil-Well Pumping Starters

G-E oil-well pumping starters are now equipped with the new G-E combination timer. Because this device combines in one unit the functions of program timing, and automatic sequence restart, it has gained wide acceptance in the oil fields. This new timer design means big savings in time and easier operation.

Program timing is especially easy. Toggle tabs which flip toward the center of the dial make control of ON-OFF operation a simple matter, even with a gloved hand. Tabs are spaced at half-hour intervals to make tab settings easy. If desired, the toggle tabs can be moved for 15-minute pumping periods.

Automatic sequence restart provided by the timer helps prevent overloading of the power supply when several motors restart at the same time after power failure. No settings or adjustments are necessary. Momentary contacts, which are closed for only a few seconds out of every four minutes, control sequence restart. After a power failure, the pumping motor will start only when these contacts are closed and the program tabs call for pumping.

Other outstanding features make the G-E oil-well pumping starter the best you can buy. Some of these features are:

- High drop-out undervoltage relay better protects motor windings. If line voltage drops to approximately 70 percent, the undervoltage relay opens the line contactor, and helps prevent overheating the motor.
- Undervoltage relay circuit provides better "single phasing" protection. Loss of power on any line prevents the controller from energizing the motor under single-phase conditions.
- Gasketed starter enclosure is designed to keep out dust, snow, sleet and rain.
- Separate ventilated overload relay compartment reduces the possibility of unnecessary tripping due to excess heat from the sun.
- 15-minute definite-sequence restart timer is available for use where a demand charge is made by the utility company.

GENERAL ELECTRIC

SEE THIS NEW OIL-WELL PUMPING STARTER AT YOUR NEAREST G-E APPARATUS SALES OFFICE OR DISTRIBUTOR—OR SEND IN COUPON BELOW.

SECTION C733-4
GENERAL ELECTRIC COMPANY
BOX 913, BLOOMINGTON, ILL.

Please send me a copy of your new bulletin GEA-6410, covering control for oil-well pumping. I want this for:

☐ reference only ☐ immediate project

NAME.....

COMPANY.....

TITLE.....

STREET.....

CITY..... STATE.....

Perfect Results with MARTIN PLUNGERS everytime . . .

Like any precision instrument or tool, there is a proper technique for the use of Martin Plungers.

1

Proper Plunger Length

The deeper the well the longer the plunger required. Three rings per 100 ft. for the 1¼" and smaller diameters, and two rings for the larger diameters, is simple rule to follow. Add extra length for stroke-thru.

2

Proper Ring Size

Gravity, Temperature and water content determine the ring size to give free travel with minimum slippage. There is no reason to have a stuck plunger, or too loose a fit. You can have any desired fit by steps of .005".

3

Proper Pre-swelling

Why run Martin Split Rings dry, when pre-swelling will get much better results? Even lube oil or grease will tighten them in the grooves, and when rolled down and tight you are assured of trouble free operation.

Complete, detailed instructions for using Martin Plungers are given simply and quickly in John N. Martin Catalog No. 4. All guess work is eliminated. You obtain proper ring size for a correct working fit, proper plunger length for your particular well, and proper pre-swelling of rings. *It's a fact: — you have perfect results with Martin Plungers everytime — regardless of water or sand conditions — when you follow the simple instructions in John N. Martin Catalog No. 4. Write for it today.*

MARTIN PLUNGERS ARE SOLD THRU SUPPLY COMPANIES

JOHN N. MARTIN

Manufacturer

9 W. BRADY • TULSA, OKLA.

STOP BREATHING

Guiberson H-2 Anchor with Type D Swivel Tension Bleed Joint

Guiberson H-2 Anchor with Type A Pressure Operated Bleed Joint

Watch lift costs go down... production go up with GUIBERSON'S H-2 *hydraulic anchor for pumping wells*

This anchor stops rod wear because it *stops breathing* — holds positively against all forces tending to cause movement of the string. Pump operation is more efficient — production is increased — lift costs are lowered.

Automatic action — no manipulation of tubing string is necessary with the H-2. As soon as fluid level in tubing is higher than casing fluid level, a series of *individual piston slips*, operating hydraulically and independently of each other, put a positive grip on the casing. Right from the start you save with the H-2 anchor. You save on first cost because the H-2 is exceptionally low cost. You save on crew time and money because the H-2 is reliable in operation — easy to set and release. You save wear and tear on your string — start lifting more fluid at lower cost.

TYPE D SWIVEL TENSION BLEED JOINT—Available in 2" or 2-½" tubing sizes. Either size shears with approximately 20,000 pounds tension at the joint. Ports in joint open when ring shears, allowing tubing to drain and thus release anchor.

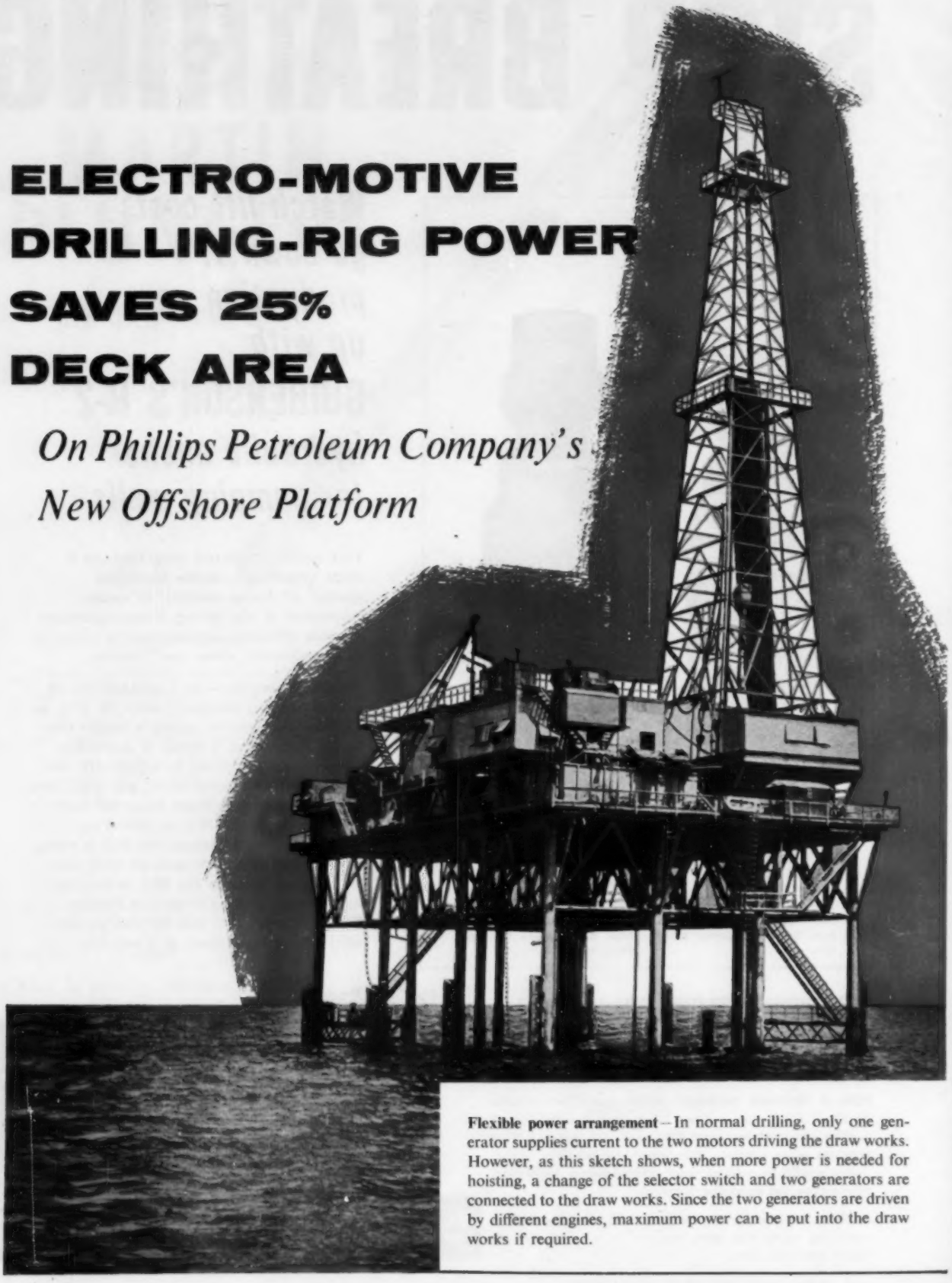
TYPE A PRESSURE OPERATED BLEED JOINT — Available in 2" or 2-½" tubing sizes. Blow plug is available in 1,000 p.s.i. increments from 3,000 p.s.i. to 6,000 p.s.i. Plug ruptures when pressure differential reaches plug rating. Joints should be ordered rated approximately 1,000 p.s.i. above expected operating pressures.

Guiberson's H-2 anchor may be released by normal methods of equalizing tubing and casing pressures or with either of the above two bleed joints.

THE
GUIBERSON
CORPORATION
ESTABLISHED 1919 • DALLAS, TEXAS, U. S. A.
Sold By Leading Oil Field Supply Stores Everywhere

ELECTRO-MOTIVE DRILLING-RIG POWER SAVES 25% DECK AREA

On Phillips Petroleum Company's New Offshore Platform



Flexible power arrangement—In normal drilling, only one generator supplies current to the two motors driving the draw works. However, as this sketch shows, when more power is needed for hoisting, a change of the selector switch and two generators are connected to the draw works. Since the two generators are driven by different engines, maximum power can be put into the draw works if required.

Most compact drilling rig in the Gulf—and farthest offshore of any yet constructed—is Phillips Petroleum Company's new unitized rig assembled on a Dome "A" platform now working 40 miles off the Louisiana shore. The platform measures only 85 by 140 ft.

Phillips chose Electro-Motive Diesel-Electric power for this new rig because it gives greater flexibility in placing equipment—saves approximately 25% in high-cost deck area.

The integrated Electro-Motive Power Plant consists of two 875-H.P. General Motors 567C Diesel engine-generator sets supplying power to five d.c. motors which drive the drilling equipment. It features simplified control and rugged dependability at a cost far below that of the few previous attempts at Diesel-Electric drives, and compares favorably with Diesel-mechanical drives.

For further information on this efficient, lower-cost drilling-rig power, write or call your nearest Electro-Motive representative. Electro-Motive Division offices located in the "oil patch" at Tulsa and Houston with other sales offices in New York City, Chicago, Jacksonville, St. Louis and San Francisco.

Features of Electro-Motive Drilling-Rig Power

Completely Integrated Design—Each of the major components designed and built to work together—*one* manufacturer—*one* source of service responsibility.

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Unmatched Flexibility—At a flick of the selector switch on the driller's control panel, power can be selected from one or more generators to meet any power requirement.

Simplified Control—Centralized position of all controls for driller's convenience—continuously variable draw-works speed control and complete rotary table torque control at the driller's finger tips.

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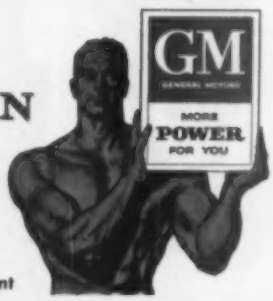

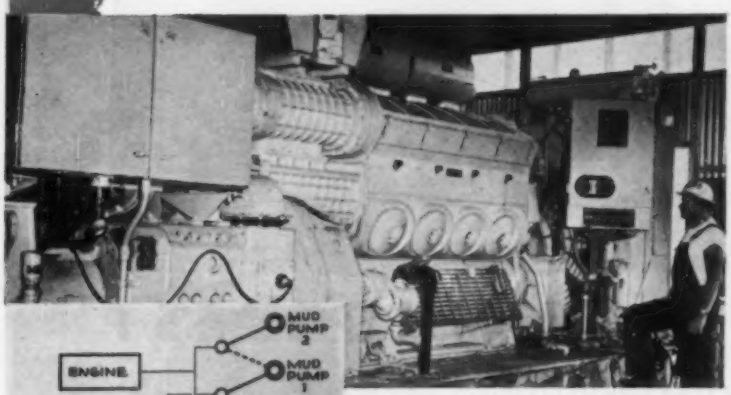

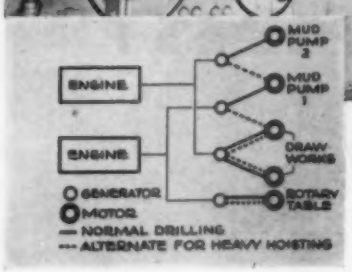

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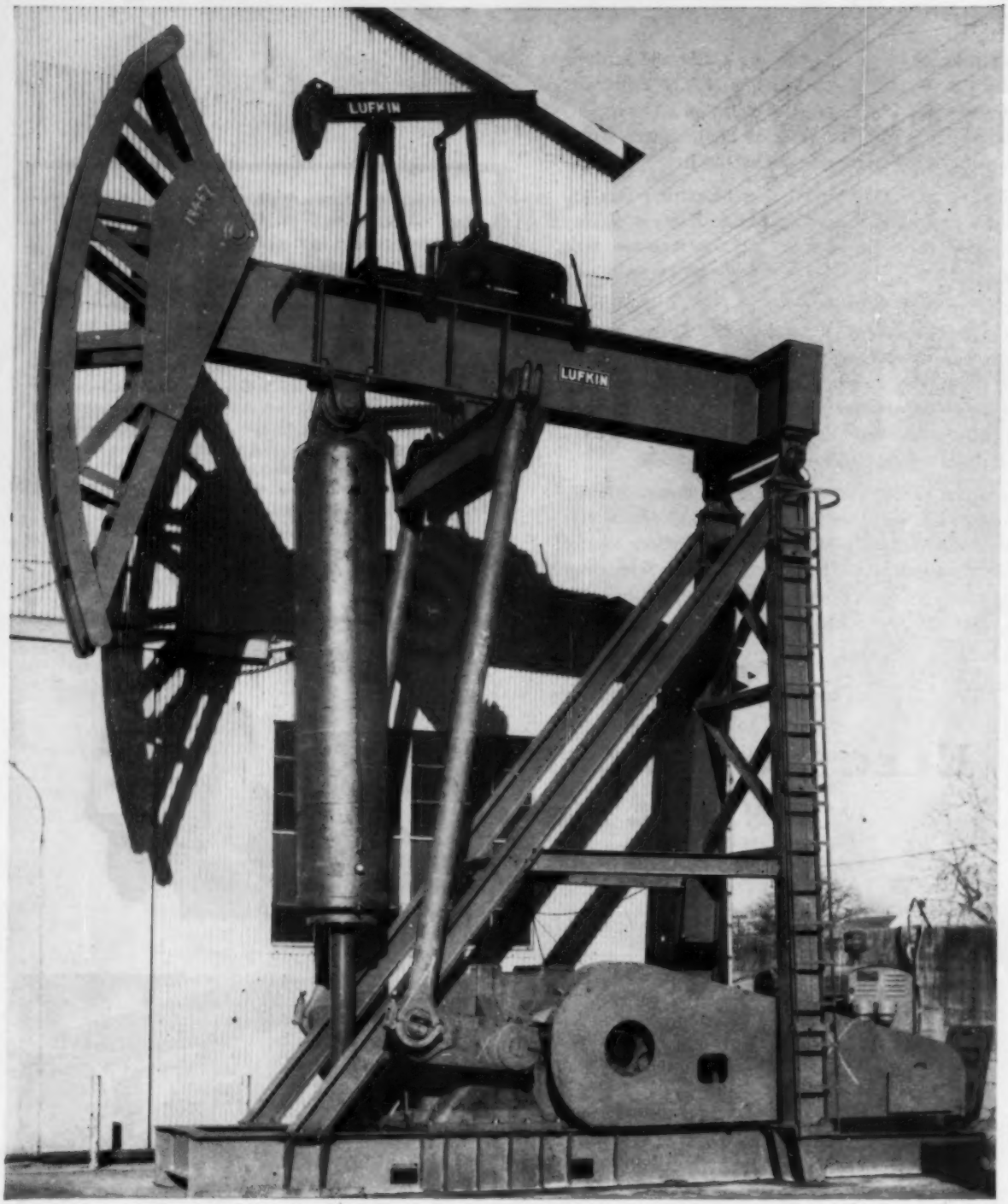

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An Announcement

It is with considerable pride that THE PETROLEUM ENGINEER announces the beginning of another informative "fundamental" series. The next page tells the background story and what you can expect in the months to come.... Here's the first.

P 500.

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FORMATION EVALUATION of Oil and Gas Reservoirs

A plan is proposed for the coordinated use of tools and techniques of evaluation by means of a key well program for studying optimum requirements for data

Norman J. Clark and H. M. Shearin
Core Laboratories, Inc., Dallas, Texas

BECAUSE we can never physically see the oil or gas reservoir in any of its in-place conditions, we must indirectly rely upon measurements of certain physical parameters to guide us in operating the reservoirs prudently. The development and operation of an oil or gas accumulation has, therefore, become a reservoir engineering enterprise; and more and more operations are logically being based on factual reservoir information in this manner.

There are two fundamental questions that face the oil and gas operator in finding, developing, and producing oil and gas reservoirs. These questions are:

1. Is oil or gas present and in paying quantities?
2. How should the deposit be produced for maximum economic return?

The reliability of answers to these fundamental questions depends upon the availability and accuracy of data upon which the answers must be based. As new oil and gas reservoirs are found at greater depths and are more costly to find and develop, accuracy of the evaluation grows correspondingly more important.

Formation evaluation encompasses the processes of gathering appropriate, accurate, and detailed data on the physical characteristics of the formation rock, the occurrence and distribution of fluids within the formation rock, and the processes of interpreting those data for accuracy and reliability so that proper use can be made of the information in developing and operating the oil and gas reservoirs. The need for accurate data is imperative, and the prudent operator attempts to secure proper information on his properties through planned formation evaluation program.

Basic data required. The basic data necessary to evaluate oil and gas reservoirs to answer the funadmental questions consist primarily of the following: (a) net reservoir oil and gas zone thicknesses, (b) productive limits, (c) porosity, (d) permeability, (e) interstitial water saturations, (f) residual hydrocarbon saturations, and (g) information on sand uniformity. These types of data separately or in combinations are needed throughout the productive life of any reservoir if employment of sound production practices is to be assured. During the development of a reservoir, the data are used to establish spacing and completion intervals of wells and to guide drilling practices. Operations of wells require the data for such

things as studies of rates of production, problem wells, and workover possibilities. Proper reservoir operations require the data for such things as reservoir engineering studies of pressure maintenance, secondary recovery, efficient rates of production, participation in production, and unitization and pooling. In addition, sale or abandonment of properties is greatly facilitated through access to reliable data.

Development of Tools and Techniques

The story of formation evaluation is virtually the story of the oil industry itself, one that was fraught with superstition and intrigue during its pioneering years; one that was spiced with fortunes and bankruptcy; and finally, one that has developed an economic stability through the support of sound engineering practices.

Cable tool period (before 1900). The period of the industry prior to the turn of the 20th century is variously termed the cable tool period, or the lamp and lubricating oil period. During this time, cable tool rigs were used exclusively for drilling, and little difficulty was experienced in evaluating formations penetrated by the cable tool drill. The presence of oil in cuttings that were brought to the surface in the bailer was easily detected, and, if the rock had sufficent permeablity to produce, the presence of oil often resulted in gushers.

As early as 1880, Carll[1] pointed out the elementary differences in recovery efficiency between the different

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The Story Behind PE's New Series...

Fundamentals of Oil and Gas Production

More than 1½ years ago, The Petroleum Engineer started something new in publication practices: A complete drilling handbook in series form. It has been reprinted twice and is still in demand.

Why this high interest in fundamentals? If you are associated with a relatively large company, chances are you have attended job training courses conducted by the company. This idea in instruction is not intended to take the place of formal engineering training. They have paid off, and such courses of practical instruction are being expanded. Field personnel are brought in from far off places to attend. Invariably, the theme of these courses of instruction goes back to basic engineering principles in all phases of oil field operations.

Our industry is becoming so complex that specialization has become necessary. It is essential that we operate as a team and understand and appreciate the basic principles governing all phases of the industry's operation. These training courses have been filling that need.

It becomes paramount that in this day of competition and rising costs those in key jobs not only "keep up" with new developments, but "refresh" themselves on the myriad of activities in his own field. These courses do just that.

To augment such training courses and to help the thousands of others engaged in producing petroleum, *The Petroleum Engineer* has set out an ambitious program to "refresh" and "keep abreast" our readers on the fundamentals of the latest practices and developments in the production of oil and gas.

In order to make this series complete in every practical aspect, your editors spent a month consulting with outstanding authorities in petroleum education as well as with many individuals engaged in active practice in the field of production. We feel we have arrived at a very complete and inclusive outline. Every effort has been made to get outstanding authorities in each specialized field to prepare the individual chapters. We are gratified that we have succeeded.

So that you might know what to expect in the months to come, only part of the outline is reproduced below. We hope to follow it as closely as possible, but it may be necessary to alter the sequence of presentation from time to time. For a complete text on Production Fundamentals, we urge you to clip out these pages.

I. Formation Evaluation.
II. Well Completions.
    1. Single-Zone Completions.
    2. Multiple-Zone Completions.
    3. Permanent-Type Completions.
    4. Selecting a Well Completion Program.
III. Casing and Casing Cementing.
IV. Perforating and Depth Measurement.
V. Placing Well on Production.
VI. Well Stimulation.
    1. Acidizing.
    2. Fracturing.
    3. Other Methods.
VII. Sand Control.
VIII. Lease Surface Equipment.
IX. Fluid Separation.
    1. Conventional Methods and Equipment.
    2. Cold Separation.
X. Field Stabilization.
XI. Field Treatment of Crude Oil.
XII. Field Records.
XIV. Artifical Lift.
    1. Rod Pumping.
    2. Gas Lift.
    3. Rodless Pumping.
XV. Automatic Lease Production Controls.

This brief outline represents only about half of what has already been definitely planned for this series.

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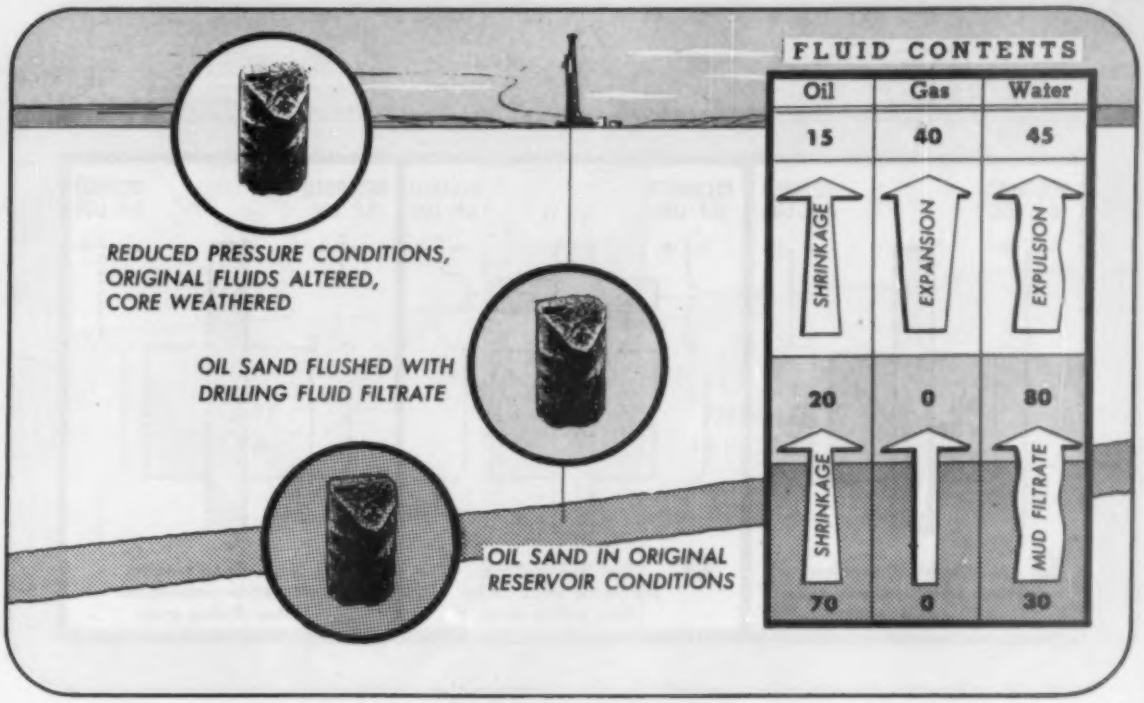

FIG. 1. CORE ANALYSIS PROBLEMS. Fluid content of the rock sample is altered while taken from original reservoir conditions to the surface.

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reservoir drive mechanisms and predicted the need for gathering data and information leading to the development of appropriate reservoir study methods. Little was done during Carll's day, however, toward development of this line of endeavor. By contrast to periods that followed, this early period of the industry remains quite insignificant in its influence on modern practices.

Transition period—cable tool to rotary (1900-1920). The advent of the rotary drill in Corsicana and shortly thereafter in Spindletop in 1899 brought in a new era in drilling. Mud in the rotary-drilled hole permitted continuous pressure control over formations penetrated and thereby a great advancement in the art of drilling wells fast and safely. While it was a wonderful advancement in the art of making hole, mud in the hole presented a great problem to the driller by preventing him from being able directly to evaluate for oil within the formations penetrated.

Millions of barrels of oil have since been proved to have been passed undetected by the drill during the years that followed the advent of the rotary rig before adequate formation evaluation techniques were developed to assist the driller in locating productive horizons. For 20 years after the rotary rig made its first appearance, a controversey ensued within the industry. Proponents of the cable tool rig considered that better information on the formations, obtained during drilling, was paramount whereas proponents of the rotary rig considered that easier and safer drilling, particularly in the soft rock areas, was paramount.

As early as Spindletop, it was recognized that some means must be devised to permit the rotary driller to examine specimens of the desired formations penetrated. Crude rotary core barrels such as punch, Texas or poor boy, auger, fishtail, and shot types were used to bring core samples to the surface for examination. It was not until 1920, however, that a double-barrel core bit was developed and became available to the industry. Although the employment of geologic methods commenced in about 1914 in the drilling industry,[2] core logs made during this period of time were based principally upon surface indications recorded by the driller or sampler.[3] These included cuttings caught at the surface, penetration rates, pipe vibrations, rainbows on mud pits, and blowouts.

Period of industry expansion (1920-1930). During the period from 1920 to 1930, the oil industry was greatly influenced by a post war inflationary trend. More oil was both discovered and produced during this decade than had been discovered and produced during the previous history subsequent to the Drake discovery.[2] Except for a general slowdown during the great depression of the early 1930's, this period marked the beginning of an industrial expansion within the industry that has continued until the present time. With unregulated production the order of the day, the industry was on a "boom and doom" basis.

Expansion in operations touched off a wave of equipment research because of the incentive to better evaluate properties, through better test methods. Ten years of core bit development followed the advent of the first double-barrel core bits before conventional bits that could be pulled without pulling the drill stem were in widespread use. Notable development included the Elliot bit[4] and the Robishaw bit in 1927. Important work was done by the Bureau of Mines[5,6] during this period in the development of laboratory procedures for core analysis, and by 1930 the industry was analyzing cores on a fairly widespread basis. Field analysis had been developed to the extent that a commercial boil-out kit was available for use by field geologists in determining core saturations on location by the solvent extraction method.

Beginning in the 1920's, a number of drill stem test patents were filed or issued on drill stem test tools that were developed to permit testing of sand penetrated with-

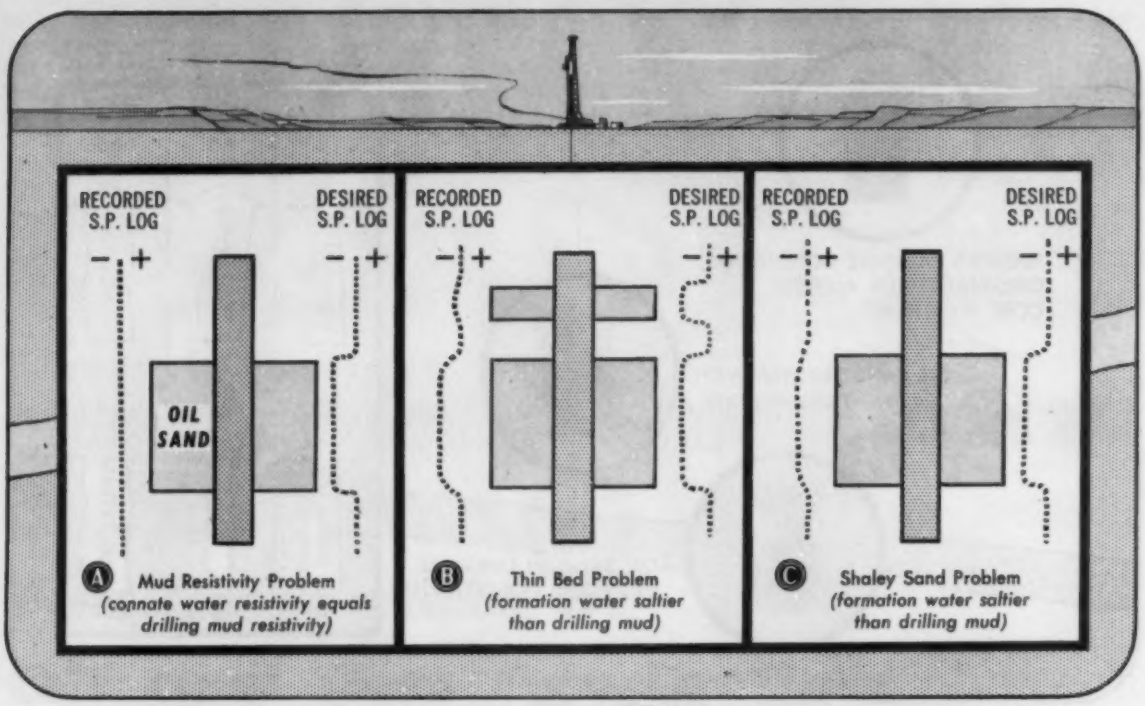
RECORDED S.P. LOG
DESIRED S.P. LOG
OIL SAND
A Mud Resistivity Problem (connate water resistivity equals drilling mud resistivity)
B Thin Bed Problem (formation water saltier than drilling mud)
C Shaley Sand Problem (formation water saltier than drilling mud)

FIG. 2. ELECTRIC LOGGING PROBLEMS. Self potential measurements are influenced in several ways, and especially so by the resistivity of the formation fluids.

out setting pipe. The first test was performed in a well near the Humble field early in 1920 by Edwards,[7] the inventor of the tool. Difficulty in tool operation and water recovery on test discouraged the use of the drill stem tester until about 1926 when a number of patents were filed on various tools. Many patent suits were ended by a Supreme Court decision that gave little encouragement to apparatus patents and no recognition to method patents because of a patent issued to Franklin[8] covering a similar device to control flow in a well.

Period of research (1930-1940). Opening with the depression and an over abundance of oil on the market, the period of 1930 to 1940 saw the industry change over from "boom and doom" operations to stability through employment of conservation principles with controlled production. Simultaneously throughout the industry, another wave of research effort was inaugurated, this time toward the development of methods to study oil and gas behavior. The industry, during the 1930's, had at last arrived, 70 years after Carll's predictions, as a widespread acceptance of the need for this type of research.

Although little development of coring tools and techniques of their use in taking cores occurred subsequent to about 1930, there were notable research developments made in the field of core analysis. The concept of relative permeability and its significance in reservoir fluid flow, together with reservoir drive mechanisms and the associated radial fluid flow concepts, were developed. These developments leads to even greater stress on developing formation evaluation techniques because the new methods of scientific study increased needs for not only porosity and permeability but also for new data such as interstitial water saturations,[9] relative permeability,[10] capillary pressure and water flood data.

Side wall coring was introduced by Schlumberger[11] in 1936 to permit examination of samples of formations that had been passed up by the drilling bit and to provide some core information at low cost on large amounts of formation exposed in the well bore.

Electric logging was developed as a possible alternate for coring to get information on reservoir rocks by means of self-potential and resistivity measurements. The first used in the United States was in California in 1929, after which it gained widespread usage as early as about 1933. The rapid growth of the use of this tool reflected the degree to which it was accepted for locating lithologic intervals, giving indications of fluids present and providing depth correlations. It did not, however, replace coring and core analysis for direct measurements of such things as porosity and fluid saturations as its inventors had envisioned. Gamma ray logging was developed in 1930, and neutron logging was developed in 1938, and, here again, additional tools were available, excellent for many purposes but not as replacements for earlier tools and procedures of logging and core analysis.

The most significant development in drill stem testing that occurred in this period was the application of the pressure gage to drill stem tests. A gage was first run in a well in 1934 in Cameron Meadows, Louisiana,[12] and such practice is now considered as an indispensable part of formation testing in order to obtain a maximum amount of formation evaluation information.

Mud logging was developed during 1938 that provided the driller with a continuous and detailed record during drilling operations. This new tool relieved the operator of a large amount of sampling and resulted in considerable savings, particularly on exploratory wells.

Application of reservoir principles (after 1940). Although interrupted for several years during World War II, the industry moved toward putting the newly developed science of reservoir engineering to work in the fields. The trend was evidenced first by several companies inaugurat-

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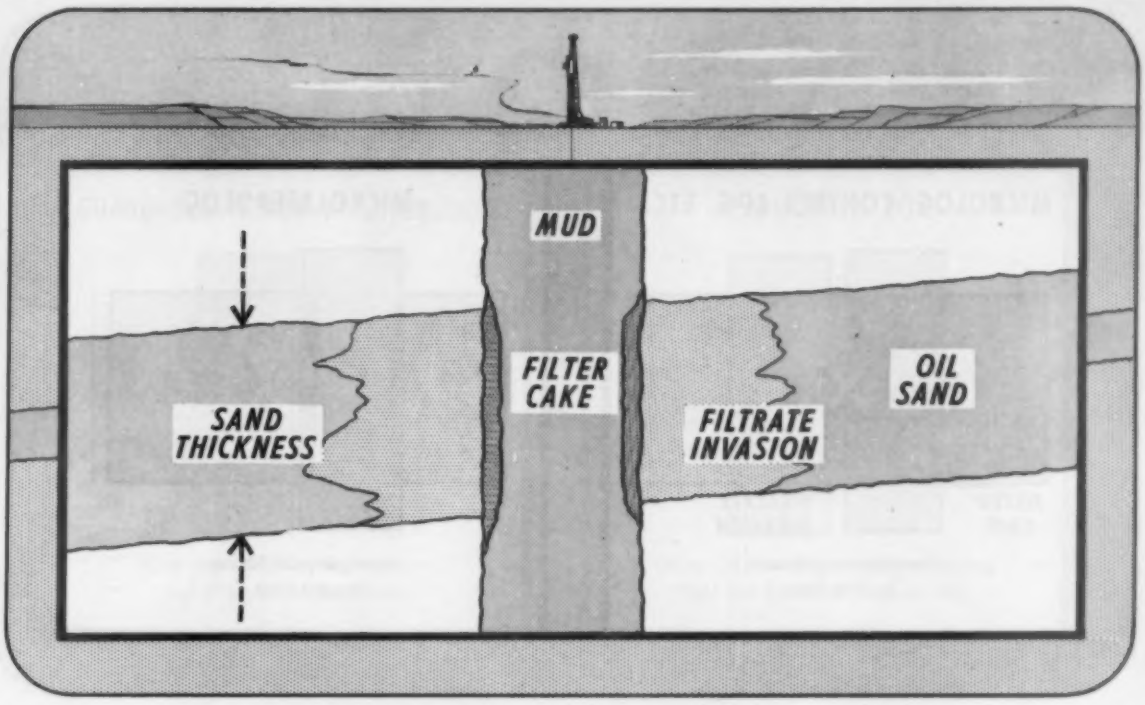

FIG. 3. ELECTRIC LOGGING PROBLEMS. The biggest to overcome are those imposed by the influence on measurements by the filtrate invaded zone, drilling fluid and mud filter cake and sand thickness.

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ing specialized reservoir engineering schools for training of their employees. The subsequent availability of trained manpower, although still somewhat short, in line with the general shortage of engineers throughout the profession during this time, brought on the need for additional quantities of accurate formation evaluation information on specific reservoirs. This need is reflected by the substantial increase in the last few years of laboratory facilities for measuring special core analyses such as relative permeability, flooding, capillary pressure, and other data used primarily for reservoir engineering studies.

A number of notable developments in logging tools have been made during the last 10 years to provide log data influenced to a minimum degree from the effects of drilling fluids and bed thicknesses. Special electric logs developed include the Microlog,[13] Laterolog,[14] Guard Log,[15] Microlaterolog,[16] and the Induction log.[17] In addition, small radioactivity logs are under development that will allow this type of log to be obtained through tubing strings. New developments in logging tools and techniques have permitted increased accuracy in formation evaluation in many situations. Quantative analysis by log measurements for porosity and water saturations is now capable of being made in a number of instances after a comparison of the results of log measurement to core analysis measurements has been established.

The overall history of the development of formation evaluation tools and techniques clearly shows that over the last 90 years there has been a geometric progression of this development that has reached climactic proportions in the period of time since World War II. New methods and techniques even today, however, must prove themselves to the industry through long processes of trial and error, and with few exceptions, at least a decade usually passes before full industry acceptance of a new technique occurs.

Problems of Formation Evaluation

Present-day formation evaluation methods include coring, logging, and testing, among which there are a large number of types and styles of tools and an abundance of techniques of comparison and interpretation of information obtained from the tools. The methods, together with information obtained and the principal source of the information, are listed in Table 1. This table shows information provided by each method that is used in answering the two fundamental questions for which formation evaluation has evolved. The vast array of formation evaluation methods, tools and techniques have not been developed over the years without their problems of use and interpretation. Such an array of tools and techniques has been developed because of problems confronting the operator at every stage of development.

Except for those of mechanical operation of tools, the majority of the problems are the result of having mud in the well bore and because it is not possible to make direct measurements on the sub-surface rocks. Fluid content of the rock samples is altered while samples are being taken (see Fig. 1) and log measurements are altered by changes in fluid content of the formations logged. This paper deals primarily with those problems pertaining to the selection and interpretation of the data to be obtained, although it is realized that the mechanical problems such as coring unconsolidated formations, or attempting a drill stem test where no suitable packer seat can be found, make the problems considerably more difficult. It is only when the problems of each method of formation evaluation are thoroughly understood that proper programs can be initiated at the right time to obtain reservoir data that inevitably will be needed to develop and operate reservoirs prudently.

Coring and core analysis. Operation of coring wells and analyzing the cores to obtain formation evaluation data

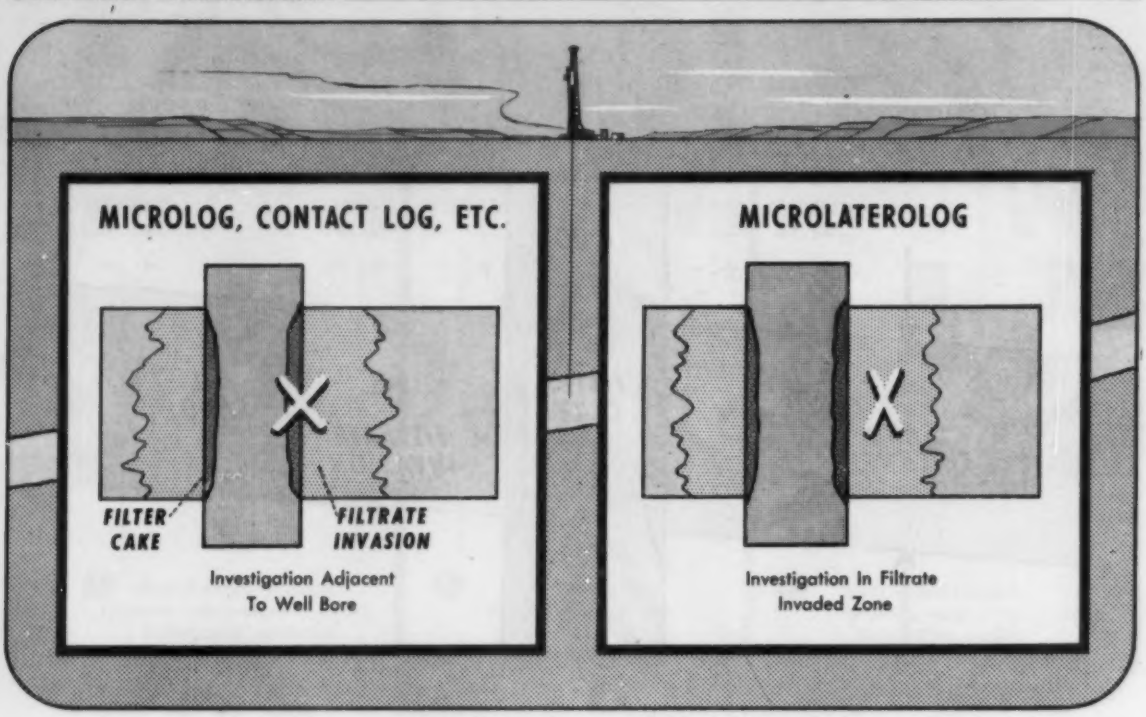

FIG. 4. EFFECTS OF ADJACENT BEDS have brought about the development of close-spaced, contact-type resistivity logs.

present usual problems that are normally encountered when information is to be obtained by a sampling procedure. The cores are actually small samples of the reservoir rock, and for the data obtained from the core to have significance either for the purpose of a well completion or a reservoir evaluation, the core must be representative of the reservoir rock.

To insure a representative sample, proper selection of wells to be cored must be made so that the available samples represent characteristics that occur throughout the reservoir both areally and vertically. Coring programs for a reservoir or a single well should be planned with the immediate objective of using the data to aid in the completion of the cored well, and with the ultimate objective of using the data to operate the reservoir most efficiently. When well-planned programs with these objectives are initiated, the problems of core recovery, core size, core handling, and core analysis measurements must be considered.

Poor core recovery makes it very difficult to locate the original position of the recovered samples within the cored interval; also, it limits the number of samples available, which in many instances prevents the data from being representative.

The problem of core size (diameter) can only be answered when the type of porosity and the data to be obtained from the core are known. Wire-line cores of 1 to 2 in. in diameter will yield reliable data for porosity, permeability, and hydrocarbon shows when pore diameter is small and no vugs or fractures exist. More difficult core analysis measurements such as water flood studies can be made more accurately when larger cores (3 to 5 in. in diameter cut with conventional or diamond core bits) are available. Porosity measurements are more reliable on these large cores if fractures or vugs constitute a substantial part of the pore space.

The problem of core handling is a mechanical problem from the standpoint of losing the identity of the cores or having them broken prior to analysis; however, articles published recently[18] indicate that cores should be protected so that, in addition, the wetting properties of the rock do not change before the core reaches the laboratory for analysis. This requires, therefore, that all the measurements to be made on the cores must be planned, if possible, before the core is obtained.

The problem of what analyses to obtain on the cores can be solved when the geologic and reservoir engineering uses of the data are understood. The flushing of the cores by filtrate from the drilling fluid while they are being cut adds other problems to the proper interpretation of the data that are obtained.

Electric and radioactivity well logging problems. Logging tools are used to give data on the lithology of the formation penetrated by the well and the fluid content of the formation. In some instances, porosity and water saturation can be extended to wells that are not cored through the use of detailed log interpretation studies. The logs are the primary source of data on the net porous interval in the formation, and log correlations reflect the degree of continuity of the reservoir.

If it were possible to make electrical measurements or radio-activity measurements on selected portions of unaltered subsurface formations, the problems of log interpretation would be greatly simplified. There would, however, still remain the problems of converting these measurements to useful formation evaluation data such as "feet of pay," water saturation, and per cent porosity. The actual logging problem is further complicated, however, because the measurements must be made in a well bore containing drilling fluids and on reservoir rocks that have been invaded by filtrate from the drilling fluid.

Development over the last 10 years of the many spe-

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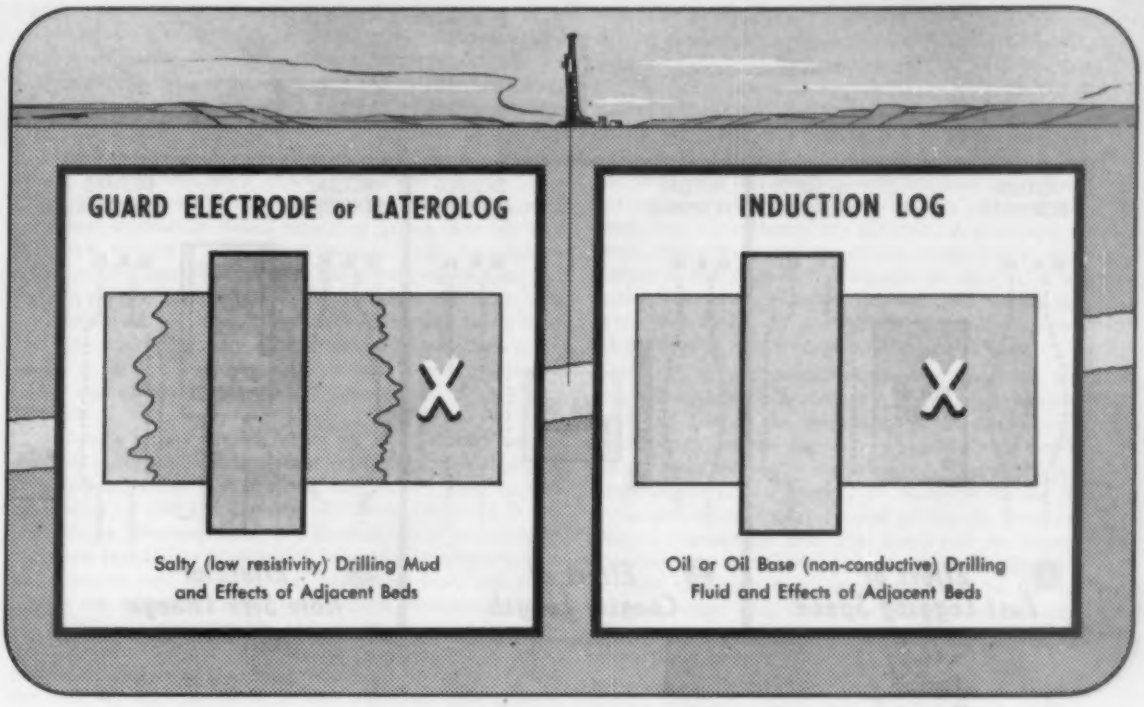
GUARD ELECTRODE or LATEROLOG
INDUCTION LOG
Salty (low resistivity) Drilling Mud and Effects of Adjacent Beds
Oil or Oil Base (non-conductive) Drilling Fluid and Effects of Adjacent Beds

FIG. 5. EFFECTS OF WELL BORE FLUIDS may be overcome by the focused type resistivity logs and magnetic induction logs.

cialized logging tools to minimize the effects of borehole conditions, bed thicknesses, and invasion have permitted answers to many appropriate problems. Availability of a large number of different logging tools has created still another problem for the oil operator. This problem is that the operator must select the type of log or logs that will yield the desired data for certain conditions.

The self-potential curve of the standard electrical survey is a measure of the current flowing in the drilling fluid primarily as a result of electrochemical action at the sand-shale boundary in the reservoir. When good self-potential curves are obtained, they provide valuable information on the sand thickness, reservoir continuity, and, in some instances, estimates of formation water salinity. The major problems involved in obtaining usable self-potential logs, however, are that (a) no self-potential curve will be obtained when the drilling fluid and the formation water have the same resistivity; (b) the self-potential curve will be suppressed when the beds are thin, and (c) the presence of shale in the sand reduces the difference between the potential opposite the sand and the potential opposite the shale (see Fig. 2).

The resistivity curves of the standard electrical survey are a measurement of the resistivity (resistance of a unit volume of material) of the material surrounding the logging instrument. This material will generally consist of the drilling fluid, the filter cake, the invaded portion, and the uninvaded portion of the porous rock. Various electrode spacings and configurations are used in the attempt to obtain values that are less influenced by the fluids in the borehole and more representative of the uninvaded formation. This means that the maximum depth of investigation is desirable in order to obtain good values of the reservoir rock resistivity. Deep investigation is best obtained by long electrode spacing, which results in averaging a greater section. This creates another problem, however, because the resistivities of the strata above and below the bed of interest greatly influence the value recorded on the log when thin beds are encountered. It is realized that there are a large number of problems that must be overcome before the true value of the formation resistivity can be obtained from the logs; however, the major problems are imposed by the influence on measurements by the filtrate invaded zone, drilling fluid, and mud filter cake (see Fig. 3).

Problems of obtaining focused-type resistivity logs (laterolog or guarded electrode log), and magnetic induction logs (induction log) (see Fig. 4 and 5).

The contact-type logs overcome the problems of bed thickness effects and give values of the resistivity of the formation adjacent to the well bore. Values of this invaded zone resistivity can in many instances be related to the porosity of the rock. The focused-type resistivity logs are designed to overcome the problem of conductive fluid in the borehole. By use of a focused-current arrangement, the current from the logging tool is forced into the formation rather than being allowed to flow in the mud. This type of log makes it possible to obtain resistivity logs when salt water mud is used. The focused-electrode arrangement also minimizes the effects of adjacent beds. The induction log makes it possible to obtain resistivity logs when a non-conductive fluid is in the well bore. This type of log is, therefore, useful when oil or oil-base mud is the drilling fluid.

A problem associated with these special logs is that many times they are not available on offset wells or wells with which it may be desirable to correlate. In many instances, certain of these special logs can be used as a replacement for the standard electric log.

Acceptance by the industry of radioactivity logging as a valuable method in formation evaluation has been accompanied by many improvements in the logging tools.

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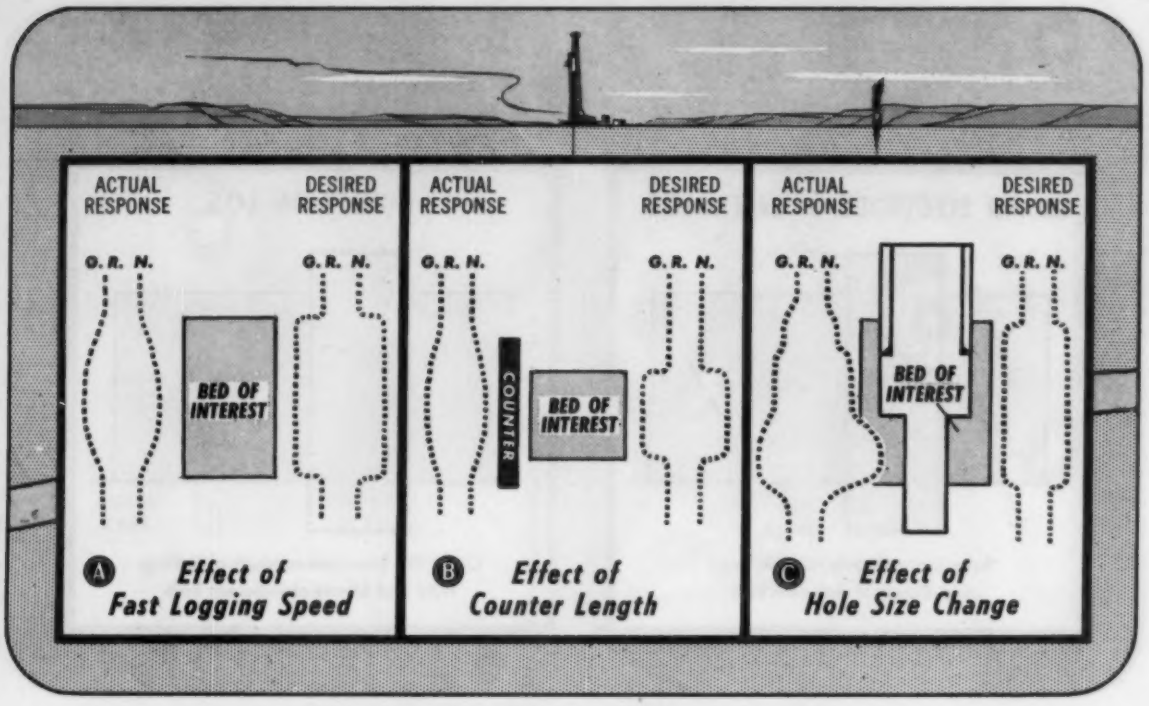

FIG. 6. PROBLEMS IN RADIOACTIVITY LOGGING stem from (A) fast logging speed, (B) counter length and (C) change in hole size.

These developments have resulted from the need to overcome problems of the influence on log measurements resulting from the changes in such things as counter lengths, hole size, casing size, and logging speed. (See Fig. 6.)

The gamma ray log is a measure of the natural radioactivity of the subsurface rock and is a valuable tool for defining lithologic changes. The neutron log is a measure of induced radiation resulting from the bombardment of the formation with high-energy neutrons. Both logs are a measure of the average radioactivity at any point in the well bore. In order to obtain this average value, a sufficient number of impulses must be recorded by the radioactivity detector. This can be accomplished by having a counter sufficiently long that it will remain opposite a given point in the well bore for sufficient time to get the average radioactivity. The long detector, however, results in thin beds being averaged with adjacent beds much like the long electrode spacings of the resistivity logging tools. Shorter counters and slower logging speeds will, therefore, give greater detail of measurements on logs. Casing and hole-size changes cause corresponding changes in the radioactivity measurements resulting in apparent shifts in the readings on the logs. This complicates the interpretation particularly when the change occurs at or near the zone of interest.

Recent developments in scintillation counters and improved geiger counters with increased detecting efficiency have provided radioactivity logs that are much more reliable than earlier logs and that aid the reservoir analyst by supplying data on earlier drilled wells where no electric logs were run, on the location of gas-oil contacts, and on the porosity of the rock.

Formation testing. A formation test is a temporary completion of the well that is made to provide direct proof of the fluid content of the formation and the ability of the formation to produce. The formation-testing phase of field development, along with coring and logging, is important for delineation of the reservoir and for establishing or confirming the gas-oil and water-oil contacts. A successful drill stem test that recovers oil or gas is considered sufficient proof of commercial production to allow some reserve to be assigned to that particular pay, and it is usually desirable to prove as many pays as possible early in the life of a field. It is axiomatic that, unless evidence is obtained that representative formation water is recovered, the absence of oil or gas on test does not prove the formation to be a non-pay sand.

Packer or packer-seat failure accounts by far for the majority of total drill stem test failures. Estimates place the total at about 65 per cent in open hole and about 25 per cent in cased hole. Plugged tools cause about 20 per cent of open-hole failures and about 40 per cent of cased-hole failures.

The length of time necessary to test a formation to adequately define the producing characteristics is categorically a problem. Length of test is influenced by such things as the length of time a test can be performed without danger of sticking the pipe, whether a bottom-hole choke or surface equipment will be used to meter volumes of produced fluids for interpreting productivity of the formation, and the length of time necessary to clean up a formation or permit flow to become stabilized. It is highly desirable, however, to close in the test and leave the tool long enough to get a complete pressure build-up curve to original reservoir pressure for use in evaluating reservoir permeability, productivity, and in checking the mud weight needed for the job.

For successful trouble-free tests to be performed, the well must be properly conditioned. Excessive rat hole is reamed, the mud circulated and properly conditioned, and a minimum shutdown time allowed with drill pipe out of the hole. The degree to which the test is properly planned determines the degree to which the test is successful.

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Proper consideration must be given to such things as type of test to use, amount of hole to test, packer size and types, location of packer seat, chokes to use, length of flowing and shut-in period, type of pressure gage and manner of use, use of water or gas cushions, and methods of handling production during tests.

The Key Well Program

It has long been recognized that the ideal program of formation evaluation would consist of use of only one tool in which complete and comprehensive, yet inexpensive data, are obtained. To this end, the producing industry, as well as service companies, are working toward improving the individual services. The combined results have been to develop more and more individual and specialized tools, which is further from the desired end of having simple, direct measurements capable of being made by a single method.

Although future developments by the industry are assured in better and more economical tools and procedures, it is not expected that a direct method of locating and evaluating oil and gas deposits will be forthcoming in the near future. Because there is a large array of present-day tools and techniques from which formation evaluation data are obtained, and these various individual tools and techniques are somewhat specialized within themselves, their use requires a considerable amount of planning in order that necessary overall information be obtained at minimum cost. This planning is done shortly after the discovery well is completed in order that all development wells be included in the program. Lack of coordination in obtaining data results in many instances in additional drilling and other expensive procedures to secure the needed information at a later date.

There are any number of situations surrounding the development of reservoirs, and the basic needs for formation evaluation data range between these situations. A key well program has been found to provide adequate data at minimum cost on new reservoir development.[19] This approach is used in a flexible manner when modified as required to fit specific cases. The following outlines such a program:

A. Selection of key wells in which to perform tests with these wells to provide for: (1) Complete information taken by all three methods—coring, logging, and testing—so that all complementary data can be studied and only useful methods utilized; (2) representative coverage of the formation, both areally and vertically; (3) savings of money by minimizing the total amount of testing.

B. Complete core analysis obtained on cores of key wells will include: (1) routine core analysis data—porosity, permeability, and fluid saturations; (2) special core analysis data—residual hydrocarbon saturations by water flooding, water susceptibility, gas-oil relative permeability, capillary properties, and electrical properties; (additional coring and core analysis are then performed for non-key wells as found necessary from studies of the information obtained on key wells).

C. The logging method that will provide reliable information is determined by comparison of log and core analysis data taken in key wells and then applied where desired in non-key wells.

D. Formation tests are performed as necessary to prove fluid content and productivity and to locate limits of production.

E. A study of all data from the various methods used in key wells is made so that unnecessary methods and procedures can be eliminated and methods that provide economic and necessary data can be retained for application to other wells. A continuous check is maintained for improved techniques and procedures and incorporated into the program when required.

The question as to what percentage of the total eventual number of wells in a reservoir should be chosen as key wells or how large an area can be represented by a key well cannot be answered directly because the geologic conditions, reservoir size, fluid distribution, and reservoir drive conditions all influence the program. A prudently inaugurated program should commence immediately upon completion of the discovery wells and be developed as information becomes available; however, successful programs have been based on one key well per 640 acres, while others require one well per 320 acres or less.

Benefits of a successful program of obtaining formation evaluation data on a reservoir occur at all stages in the operating life of the reservoir. These stages are during development, where proper spacing and well completions are of great economic significance; in production operations, where proper control of reservoir drives may enhance greatly the recovery and profits; in pressure maintenance operations that are employed to increase the economic value of the reserve; in secondary recovery projects inaugurated to renew and add to the value of the properties; and, finally, in abandonment of the properties to prevent the abandonment or sale of undeveloped economic reserves.

Benefit to the operator of a successful program of obtaining formation evaluation data is found in the availability of the proper data in usable form at the time needed and at a reasonable cost.

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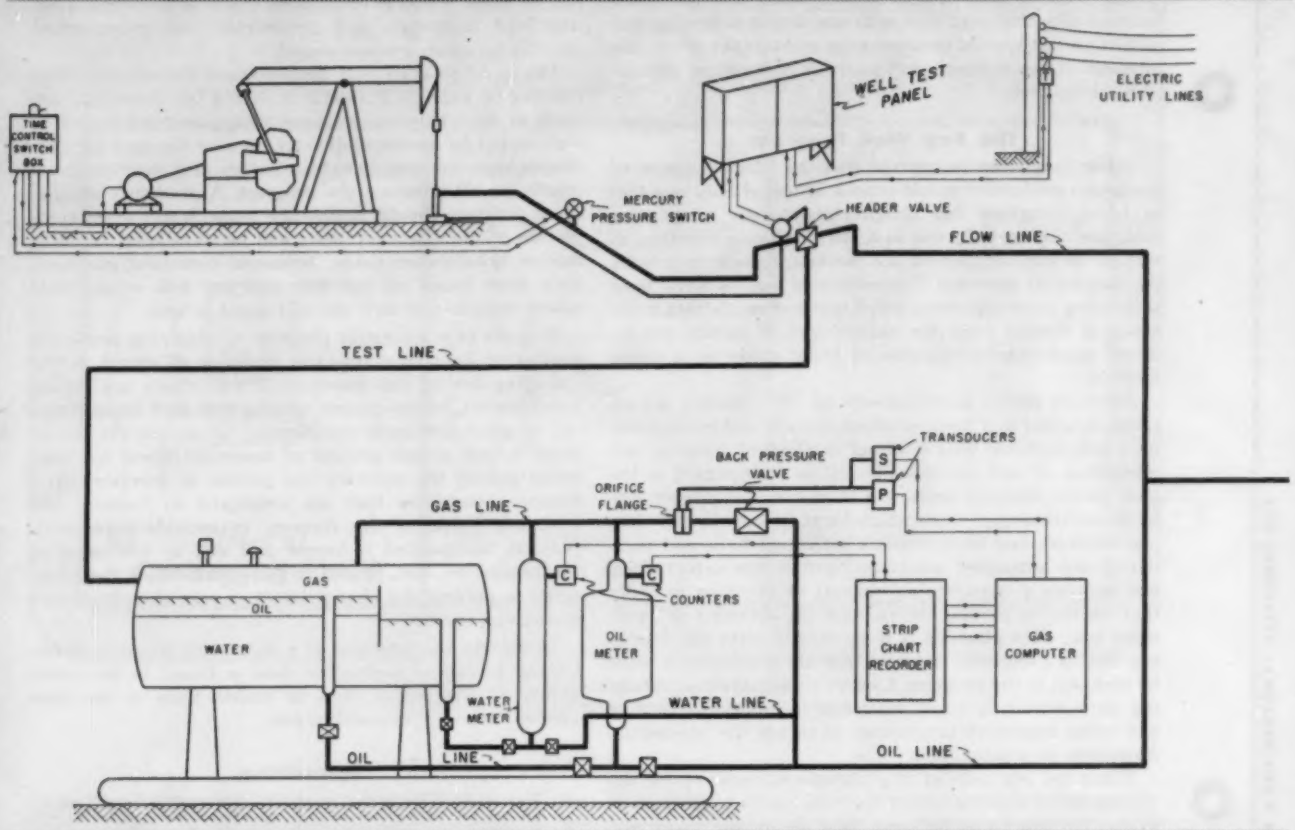


87-Well Lease Fully Controlled by . . .

New Production

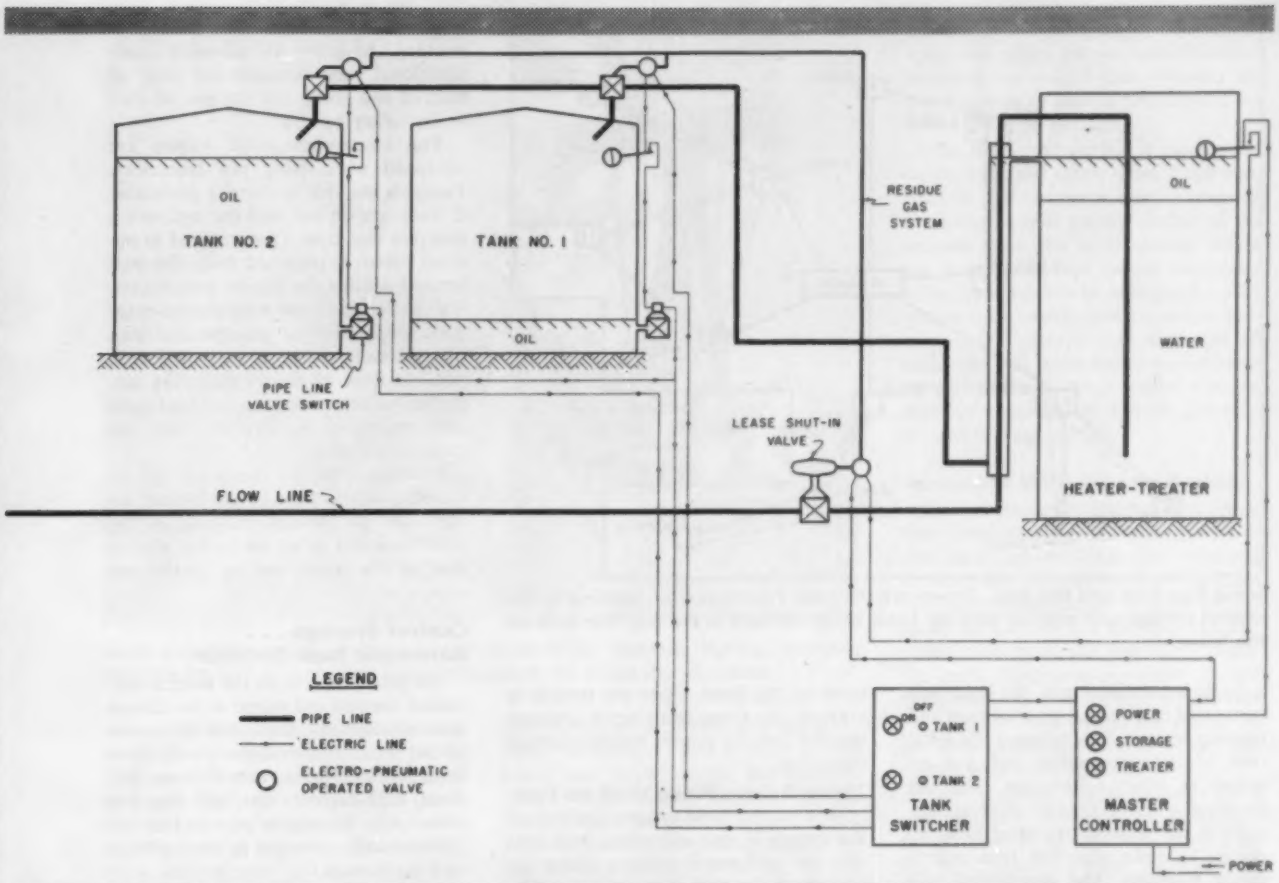
- Gas flow computed by new electronic integrator
- Fluid measured by automatic positive displacement dump meters
- Quarterly well tests performed automatically

James A. LeVelle
Engineering Editor

EXCLUSIVE

A Lease-wide control system capable of handling production from well to lease tanks and performing periodic production tests has been installed by a West Texas operator. Started in the spring of 1955, the conversion to automatic operation was completed the first of this year. The installation is not considered to be experimental; it is designed to reduce lifting costs and increase operating efficiency of the lease.

Covering some 6800 acres and 87 pumping wells, the lease is operated by two pumpers. By eliminating the manual operation of pumping units, valve manifolds and other lease equipment, pumpers are able to spend a greater portion of their time in maintenance and overall lease-operating requirements. It has resulted in the improvement of the lease operation and re-



Schematic diagram of lease control system. Unit controls production from the wellhead to lease storage tanks through a unique system of timers and switching equipment. Individual wells are automatically tested for periodic production tests.

Programming System

duced equipment downtime. Quarterly well testing by manual techniques required a considerable number of days to perform tests and compute results. With the automatic well-testing unit now in use, tests are made on wells in the lease in less than 15 days and with a minimum of calculation.

Automatic tank switching controls and safety equipment on the central lease storage system has eliminated the need for multiple checks and constant supervision during the operating day. Pumper is required to check the central system only once each day. Gaging and manual operations are required in making pipe line runs.

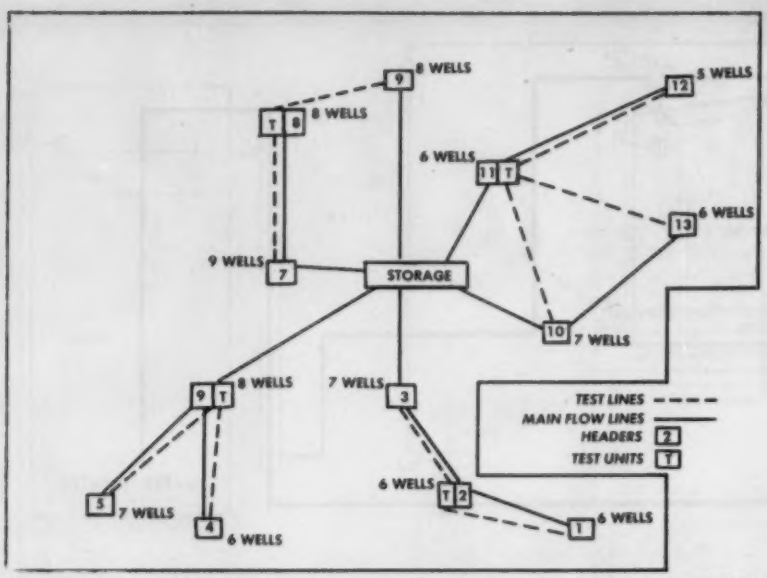
Lease System

Basically, the lease operating system may be divided into three units: The gathering system, automatic well-testing system and central lease storage and treating unit. Timer-relay units are used to operate individual wells and to place wells on test. The central storage unit is equipped with an automatic tank switching installation and safety shut-down controls. A large portion of the control components are field proven units that have been used for some time.

A multiple-header type flow line system is used due to the irregular shape of the lease and to reduce the length of flow lines. Thirteen headers, handling production from 6 to 8 wells, are strategically located within the lease boundaries. Each header is equipped with a manifold made up of electro-pneumatic two-way valves that can be operated to direct flow into the gathering system or into the test line. Test lines lead directly to one of the four production tests units in use.

In normal operation, production from the well flows through the header directly to the central heater-treater installation and from there to the lease storage battery. In testing, the well stream of the well on test is diverted to the automatic production test unit where water, oil, and gas are separated and individually metered. After metering, production components are commingled and injected back into the main gathering system.

Prior to the present installation, the treating and storage facilities were decentralized, requiring 5 tank batteries located on the lease. Since the cost of automatic equipment would be considerably more than that required for



Lease flow lines and test lines. Shown are the main flow lines from headers to the central storage unit and the well test lines, which are laid to the four test units on the lease.

a single centralized unit, the lease was converted to a central lease storage and treating system. This reduced the inital cost of instrumentation and has resulted in other advantages over the previous method. One of these advantages is the reduced traveling time required to make pipe line runs and to check facilities. The centralized unit will also simplify the installation of future equipment such as salt water disposal units, etc., that might be required at a later date.

Pumps Operate on Time-Relays

All 87 wells on the lease are pumping and are equipped with conventional rod pumping units driven by electric motors. Each unit is equipped with a timer-relay unit and motor controllers that automatically start and stop units on a preset pumping cycle. The pumping cycle is determined from periodic well tests. The time control can be readily set by the pumper to conform to the individual well requirements.

In addition to the timer circuit, each pumping unit is protected by a mercury high-pressure switch located near the wellhead. This switch disrupts the power supply to the unit if high pressure is encountered in the flow line. The switch is set to shut the unit down when pressure reaches 110 psi and to place the pump back on the line when pressure drops below 80 psi.

This switch also plays an important part in the overall lease-control system. If the lease shut-in valves at the central storage unit are closed due to full tanks, etc., the resulting overpressure in the flow lines will shutdown all pumping units on the lease. Once the trouble is cleared, the timer-relay again assumes control and the pumps resume normal operation.

Timer-Relays Place Well on Test

One of the most unique features of the system is that individual well tests may be performed without undue attention on the part of the pumper. The header units are provided with an automatic timer system that selects the wells to be put on test. The manifold unit is equipped with electro-pneumatic two-way valves that are operated by a timer-relay panel at the header. In normal producing operations, flow is directed into the main flow line header. During test periods, the timers, one for each well in the group, operate to place one well at a time into the well test flow line. Controllers are now available that require only one timer for all the wells connected to the header, rather than one timer for each well. Based on a preset schedule, the well is switched into the test lines for the desired test period. At the end of the test, flow is switched back into the gathering system and the next well placed on test.

This testing period may be varied from 0 to 24 hr by resetting the timer controls located at the header. If necessary, the valves can be manually operated.

The timer circuit is interlocked so that only one well in the header group may be placed on test at any one time. Sequence of testing is fixed so that wells will be tested in the same order each time and to simplify the identification of the test results recorded. Interlocking controls are not provided between headers. Interference during tests is avoided, however, by allowing some additional time between the start of tests of one group and the end of tests at the other header.

The electro-pneumatic valves are equipped with rising pin indicators. Pumpers are able to visually determine if wells are on test and the well being tested at that time. Gas required to operate valves is obtained from the well located nearest the header installation. Valves are equipped with electro-magnetic pilots and a gas-operated diaphragm motor valve. In case of electric power failure or loss of operating gas, the valves return to their original position and flow is directed into the gathering system.

Emulsion breaker chemicals are injected into the lines at the header installation to prevent sludging in the flow lines and as an aid in the separation of the water and oil at the test separator.

Central Storage . . . Automatic Tank Switcher

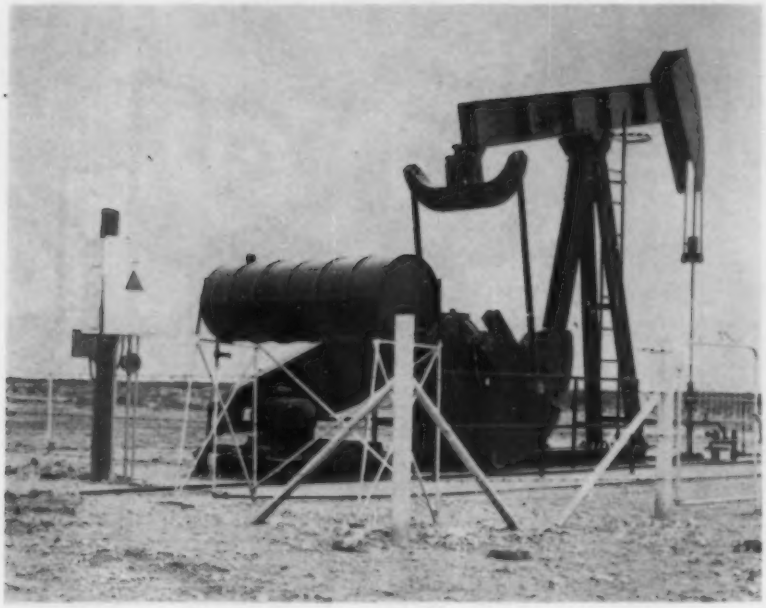
All production from the lease is separated, treated and stored at the central lease storage unit, located in the center of the lease. It is equipped with three heater-treater units; one a large 8-ft diam, high-capacity unit and two 6-ft diam units. Storage is provided by ten 500-bbl tanks arranged in two batteries of 5 tanks each.

Controls are provided to select tanks and automatically switch flow into the tanks. Also, the system provides protection to the unit from overfilling, overflowing of the treaters, or electric failure. Either of the above conditions causes the lease shut-in valves to close. Three valves are used and are located just ahead of the three heater-treater units.

Control circuit used might be described as functioning on the open circuit or interruption-of-power principle. The main valves or lease shut-in valves are of the fail-close type of valve, operated by loss of energy to the valve motor. All valves in the system are of this type and are operated by an electro-magnetic pilot valve and use a diaphragm-valve motor. It might also be pointed out that the gas supply is residue gas from the gasoline plant. Valves are also set to close if the supply of gas is interrupted.

Operation of the Tank Switcher

The heart of the control system is the tank selector and switch unit. This unit selects the tank to be filled and automatically switches to the next empty tank when full. Components that make up the control include a master control unit and mechanical selector unit. The selector is cam or mechanical



Each pumping well is equipped with timer-relay controls. Mercury-pressure switches on flow line play an important part in the lease shut-in system.

type of switching gear. Included in the circuit to each tank is an electro-pneumatic tank header valve, a float switch, and a pipe line valve switch. This latter device is attached to the pipe line valve on the tank to prevent filling tanks when making pipe line runs from the tank. When the valve is open, the circuit to provide the same response if the tank were full.

The tank selector is a multiple cam switch driven by a small motor. Starting at the number one tank, the unit energizes the electrical circuit to the number one tank. The circuit is completed when the float switch is closed and pipe line switch is closed. The header valve is then energized and will open to allow oil to flow into the tank. Flow of electric current through the completed circuit stops the selector motor. The selector remains in this position until the current is interrupted by the float switch opening, indicating that the tank is full.

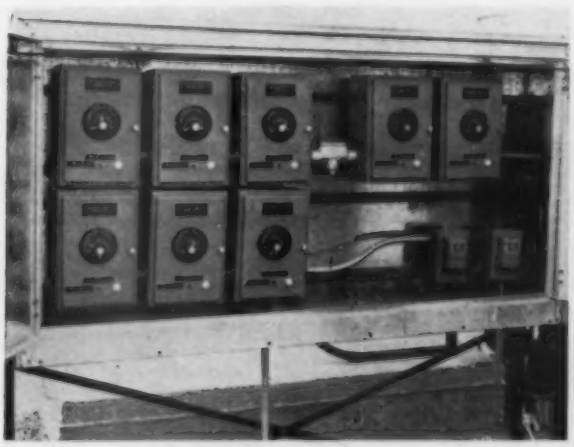
When the fluid level raises the float, breaking the circuit, the selector motor rotates the selector to the next tank contact or until an empty tank is found. If any empty tank is found, the cycle is repeated. If storage space is not available, the selector stops and the master control de-energizes the unit, closing the lease valves. A 10-sec delay is provided in checking each tank circuit to prevent excessive hunting in the control and to allow for some delay in the operation of the valves. Added delay is provided by the selector between the two batteries to permit equilization between the tank headers.

The master controller is installed in series with the safety float level controls in the heater-treaters. Using an open-type system similar to that of the selector unit, the lease shut-in valves are actuated by the master controller when the circuit is de-energized by the treater float switch, electric power failure, or the selector indicating that all tanks are full. Pilot lights on the master unit indicate the cause of trouble, whether it be power failure, treaters, or tank storage section.

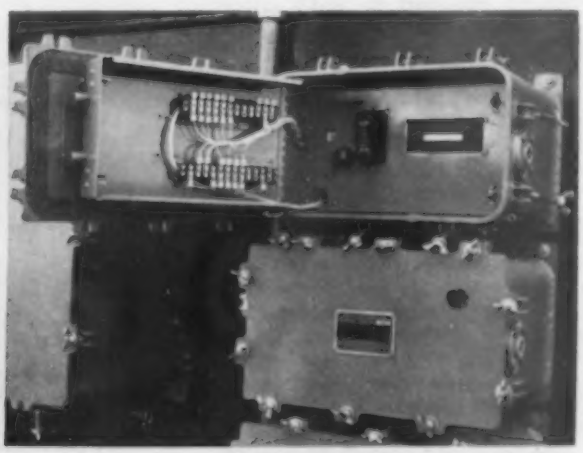
Automatic Well-Testing System

One of the newly developed automation components used in this system is the packaged well-test that operates more or less independently of the main production and storage systems on the lease. Its purpose is to periodically test production from the individual wells. Its main components consist of the timer-relay system located at the various headers that switch the stream of the well to the test flow lines and the automatic testing unit.

Test unit is completely skid mounted and only requires connection to the flow lines and to a supply of electric power. Power required is 110 v, alternating current. The unit consists of a small horizontal separator, a water metering unit, oil metering unit, and a gas flow measuring unit. A three-pen strip chart is used to record test results. Unit is designed so that the quantity of water, oil and gas flow rate is automatically determined and recorded in the test period. The rate flow capacity of the units is 500 bbl of oil per day.



Timer-relay panel at header installation. Each well is individually switched by the control unit into the well test system.



Gas flow computer, enclosed in explosion-proof, dust-proof housings, provide the flow rate in cubic feet per hour.

Four test units are located throughout the lease. The header to which each unit is connected and the number of wells serviced are as follows:

Test Unit	Header Unit Numbers	No. Wells in Group
No. 1	1, 2, & 3	19
No. 2	4, 5, & 6	21
No. 3	7, 8, & 9	23
No. 4	10, 11, 12, & 13	24

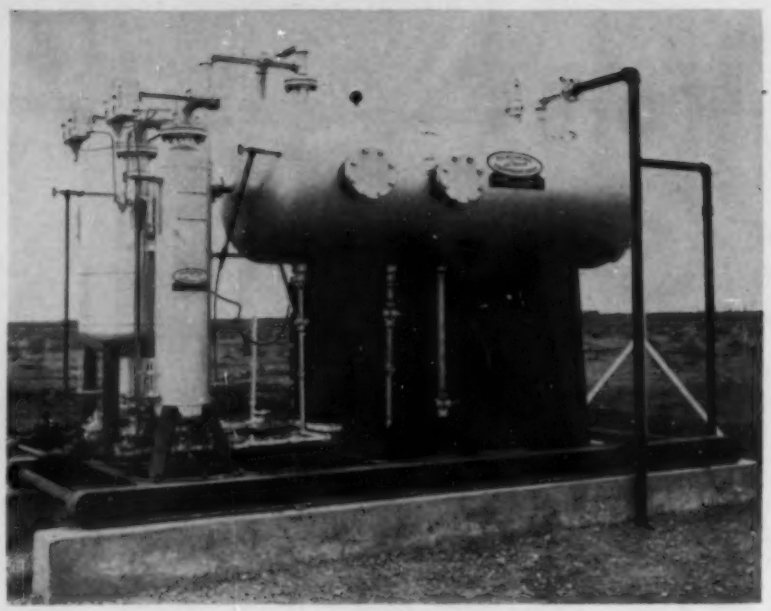
Gas Flow Rate Measured In Cubic Feet per Hour

Two measurement devices are incorporated in the test units. The volumetric or dump method is used to meter the oil and water. Gas is measured by a new anolog gas computing unit that records the flow rate directly in cubic feet per hour. This device utilizes a conventional orifice meter and a transducer computer system that translates pressure readings into corrected flow rate at standard conditions.

The gas flow meter consists of an orifice meter, two pressure transducers, a preamplifier unit, a new type of anolog computing unit, and a recorder. The transducers translate the static and differential pressures of the orifice meter into electrical impulses. These are amplified and fed into the computer unit. The electrical components that make up the computer in effect calculate the corrected volume of gas based upon the static and differential pressure readings. The wiring and elements are designed to solve the formula, $Q = C\sqrt{h_w P}$, where C is the orifice constant. Plug-in units about the size of a package of cigarettes provide the orifice constant C for the above formula and compensate for the various orifice sizes. One unit is used for each orifice plate size, and each plug-in unit is well marked to show the proper plate size and other pertinent information. System is designed to prevent errors and to permit in experienced personnel to make orifice changes with a minimum of difficulty.

The temperature, specific gravity, and other properties of the gas at the test unit have been found to be more or less constant with the result that automatic compensating units have been required in this installation. The proper correction constant for the gas properties is set in the computer by the operating engineers. Field tests indicate that the results obtained are well within the accuracy possible with conventional calculating methods and under some conditions have been found to be considerably more accurate. By providing the flow rate in usable terms, time has been saved in determining gas oil ratios.

At the present time, charts must be manually integrated to determine the total gas flow during the test periods.



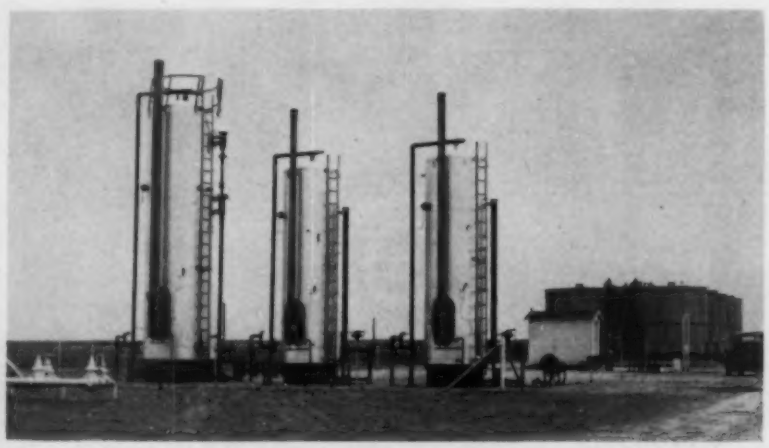
Well testing unit. Equipment is skid-mounted package that only requires connection to flow lines and a source of electric power.

Provision has been made, however, to install an integrating unit at a later date that will automatically read or provide the total flow. Operators plan to use an integrating device that will provide a "pip" or kick on the recording chart rather than a numerical system. The device would give a small "pip" each 100 cu ft and a large "pip" every 1000 cu ft. In this manner, the total gas flow would be easily read by counting the number of pips in the test period. Also, the average flow rate in any short period could be readily determined from the chart. This is of particular importance in this installation since it would enable the operator to determine if wells were pumping off, gas locking, etc., and aid in evaluating the pumping cycle.

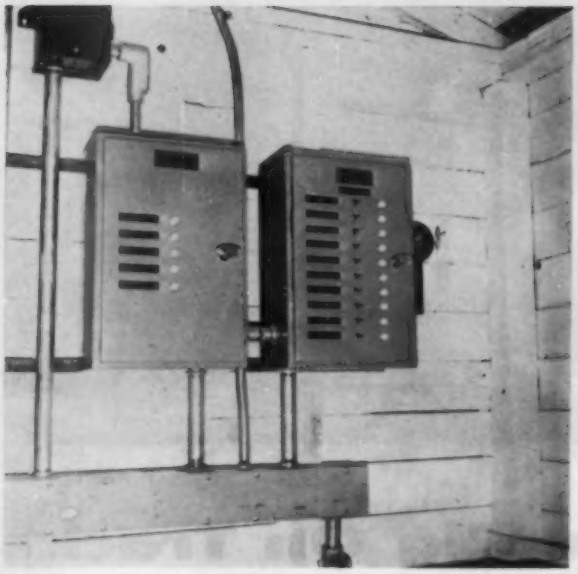
With the exception of vacuum tubes used in the preamplifier section, normal tube requirements are satisfied by the use of magnetic amplifiers. Magnetic amplifiers require less power and are less suspectible to weather conditions. The resulting equipment is exceptionally rugged and insensitive to vibration and temperature. All electrical components in the system are housed in explosion-proof, dust-proof boxes mounted on the skid frame.

Oil, Water Measured by Dump Meters

Another development built into the



Central lease-storage unit is equipped with automatic tank switching controls and an automatic lease shut-in valve system.



Tank switcher controls filling and switching operations in lease storage battery consisting of ten-500 bbl tanks.

Float switches, tank header valves, and pipe line valve switches as shown are installed on each tank in the battery.

well-testing units is an automatic, positive-volume type liquid meter, commonly referred to as a dump meter. The meter consists of a calibrated chamber that is automatically filled and dumped to provide a measure of the fluid flow. The total volume is obtained by counting the number of times the unit dumps and the volume of the chamber. On the unit, a one-fourth barrel chamber is used to measure water and one barrel chamber is used to meter the oil.

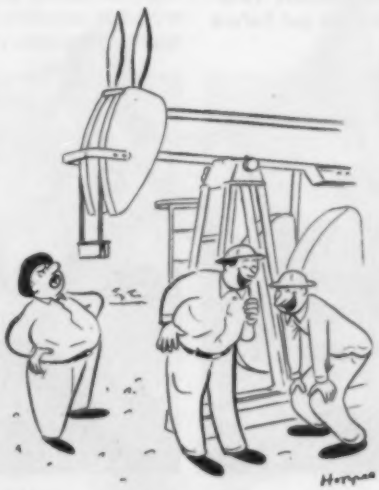
In operation, the chamber is equipped with float valves that actuate a two-way pilot valve. This valve energizes the two pneumatic-operating valves that fill and dump the chamber. In filling, the dump valves is closed and the upstream valve is opened. Upon reaching a present level, the float actuates the pilot valve to close the filling valve and open the dump valve. On completion of the dump, the lower float valve reverses the position of the valves. Quick-acting pneumatic valves are use don the unit, maintaining the accuracy of the meter and reducing the possibility of loss caused by valve lag.

Accurate setting of the high and low cut-off points and routine adjustments are made in the field. Gage glasses on the units permit visual checking to see that meters are functioning properly and are used to set the cut-off points.

Strip Chart Makes Record of Test

The measurements provided by the gas flow meter and the dump meter are recorded on a single three-pen strip chart recorder. The center pen traces the instantaneous flow rate, and the number of dumps or cycles of the dump meters is made in the borders of the chart. The chart for the well under test is identified by the hourly markings and a knowledge of the preset testing schedule. Volume of water is obtained by counting the number of marks in the left hand border of the chart and dividing by four. Barrels of oil produced is directly equal to the number of pips appearing in the right-hand border.

A back-pressure valve is installed down stream of the orifice meter to maintain a pressure in the test unit slightly higher than that of the lease gathering system. This permits the products from the tests to be injected back into the system following the test.



All right! Who put ears on the mule head?

Typical Test Operations

The maximum test that has been handled by the test units in the lease flowed 80 bbl of oil, 10 bbl of water and measured a gas-oil ratio of 350. However, a typical test obtained from the recorder shows 21 bbl of oil, 2 bbl of water and a gas-oil ratio of 350 measured in a 24-hr test period. The results of the tests are considered by the operators to be well within the accuracy obtained by conventional test methods. Reliability of the unit has been excellent, and no undue problems are anticipated at this time.

Only Trouble on Lease System is Time

While no trouble has been encountered with the automatic equipment, an unexpected difficulty was found in setting up schedules. As previously pointed out, the pump installations and testing schedule are both regulated by timer systems. Some difficulty has been encountered with the overlapping of tests from different headers and with the pump timers shutting down the units in the middle of tests. The situation was remedied by rigorously scheduling the well operations and that of the testing cycle. Also, additional time is allowed between tests from different header units to prevent overlapping. No further trouble has occurred with this improved method of scheduling. ★ ★ ★

First rigup on Texpet's 2½-million acre concession in Peru is the Company's track-mounted light rig on location at the Maranon 8.1 wildcat well. Drill tubing rather than drill pipe is used. When this photo was taken, well was down to 7400 ft.

Peruvian Wildcat Underway as . . .

P 422.12

Texpet Moves in Rig On Tracks

Track-mounted drilling rig unloaded from LSM by tractor after long journey up the Amazon River across Venezuela and deep into Peru. The rig was unloaded just before the rainy season ended.

Major items unitized on tracks for mobility in rough terrain. Equipment barged up Amazon River.

TEXAS Petroleum Company, a wholly-owned subsidiary of The Texas Company, is nearing the bottom of their first wildcat well on a 2.5-million acre concession in the Maranon River Valley of Eastern Peru. Major items of rig equipment were mounted permanently on trailer bases equipped with tracks. This unique design feature enabled Texpet to move the rig easily from an LSM (a military surplus vessel) onto the soft, rough terrain 2½ miles from San Lorenzo on the south side of the Maranon River. The equipment had to be barged up the Amazon River some 3500 miles to its present location. The photographs to follow indicate some of the problems involved in handling heavy drilling equipment in this remote region. All photos courtesy The Texas Company.

Rigging up on Texpet's first exploratory well in Peru. Note how all major equipment was track-mounted to facilitate move. Well site is about 300 ft from the banks of the Maranon River.

Tubular goods are unloaded from barge by tractor boom crane on banks of the Maranon River at site of Texpet's first exploratory well in Peru.

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Study Committee Reports on...

HYDRAULICS OF ROTARY DRILLING

Four-year study in Gulf Coast and Ark-La-Tex areas on jet bit drilling shows:

- **Greater benefits from increased jet velocities with lower rotary speeds.**
- **Two smaller sized pumps preferable to one larger pump.**
- **Oversized drill collars successful with jet bits.**
- **Annular velocities of 150 fpm and less satisfactory with jet bits.**
- **Optimum hydraulic effect attained by 70 per cent of total pressure drop across nozzle.**
- **Highest drilling rates obtained when hydraulic hp and bit weights were greatest.**
- **Minimum nozzle velocity established at 190-200 ft per second.**
- **Maximum practical nozzle velocity approached at 250 ft per second.**

Texas Gulf Coast Area

T. W. Keating
Stanolind Oil and Gas Company
Houston, Texas

THE idea of a study committee on jet-bit drilling was put into motion at the 1951 Beaumont Spring meeting and organization was accomplished at the Shreveport meeting in 1952. It was believed that such a committee could be of educational service to the drilling industry by reviewing what was already known, accumulating additional information and presenting the results as a paper at a suitable regional meeting. The following outline was developed:

1. Study to include jet applications of both drag and rock bits.
2. Recommend proper applications of hydraulic hp in drilling.
3. Determine practical optimum limits of hydraulic hp required, with due attention to: (a) annular return velocity; (b) nozzle jet velocity; and (c) pressure-volume relationships.
4. Prepare a form for recording and reporting drilling data with hydraulic data.
5. Members to contact operators to encourage recording and reporting pertinent details. Bit manufacturers to help committee members. Reports to include poor as well as good results.

Accordingly, later in the year it was decided to set up separate subcommittees for each section of the then-existing Southwestern District, to permit more convenient and frequent meetings to review the progress in accumulating the desired information. These sections were: Central West Texas, Arkansas-Louisiana, Louisiana Gulf Coast, Texas Gulf Coast, and Southwest Texas.

At one of the early district meetings, the suggestion was made that the name of the study committee be changed from "Jet-bit" to "Hydraulic Horsepower" because the problem involves not simply nozzle velocities but also mud properties, hole sizes, drill string, surface connections, pump size, available rig power, weight on bit, drill collars, stabilizers, rotary revolutions per minute, types of bits and formations and actually includes nearly all drilling factors.

There were general expressions of the desirability of better records and reporting. Extremely few reports were made of operations with low hydraulic horsepower to compare with those with high hydraulic horsepower. Also, in the Gulf Coast there were relatively few conventional nozzle bits run to compare with jets.

Hope was expressed that the new

Editor's Note: For purposes of this study, the committee on jet-bit drilling was divided into three sub-committees headed by the following: (1) Texas Gulf Coast, T. W. Keating, Stanolind Oil and Gas Company, Houston; (2) Louisiana Gulf Coast, W. D. Clift, Humble Oil & Refining Company, New Orleans; and (3) Ark-La-Tex, John Cutrer, Reed Roller Bit Company, Shreveport. The full report was necessarily made in three parts and are present here just as they were given at the API Southern District meeting held in San Antonio, Texas, March 7-9, 1956.

AADC-API standard drilling report form might encourage better reporting because of having subheadings and spaces conveniently available for entering all the various desirable data.

It was suggested that special effort be made to obtain further reports from active fields such as Amelia, Mustang Island, Chocolate Bayou, North Silsbee, East Hillister, etc. Another suggestion was that some of the offshore operations might provide similar wells for comparisons of varying hydraulic programs. Various operators were contacted on this, but returns were meager.

The observation was made, however, that the jet-bit questionnaire has greatly benefited field thinking and reporting on jets even if conclusive data are not yet accumulated.

Some reports indicated more benefit from increased jet velocities at lower rotary revolutions per minute than at high revolutions per minute, not only in easy drilling, but also in medium-hard drilling.

What reports showed. A practical limitation on high jet velocities was considered to exist in some shallow drilling with sandy muds which are too erosive.

- Plugging of small jets can be a problem. Strainers on pumps are important. Breaking circulation before getting to bottom helps in some cases.
- A question as to relative efficiencies of a single big pump compared with compounded pumps brought the statement that, by compounding existing pumps, there had been 30 to 45 per cent increase in rate of penetration; and furthermore, operation was not too seriously impaired by stoppage of one pump. The other pump could continue at about two thirds of the volume rate. Also, a greater range of pressures and more days of operation might be covered without changing liners with two compounded pumps as compared with a single big pump having the same power.
- Compounding in series has an advantage also over two pumps in parallel in that with one of the latter down, the drilling efficiency with only "half circulation" is very low.
- It was emphasized that for compounding power pumps there must be an efficient pulsation dampener both between the pumps and after the second pump. Also, separate drive is used. This may involve a few seconds longer for restarting after a connection.
- Mention was made of considerable trend toward increasing the speeds of existing power pumps to provide wider coverage of hydraulic requirements. It was observed that various items of rig equipment need improvement to suit the higher hydraulic power application involved in jet bits. Lack of pressure ratings on swivels is an example. There must be, of course, an economic balance between benefits from jets, and extra rig requirements.
- Sometimes lease requirements justify a higher-cost rig just to get a well down before a certain date. On the other hand, the current slim-hole trend is toward smaller, lower-cost rigs that may drill slower but still accumulate less total cost. Smaller holes tend to drill slower because of the lesser proportional weight that the small bit bearings can stand.
- It was reported that oversize drill collars have been successful with jet bits because of the emphasis on good circulation and big pumps, thus keeping the hole clean.

Annular velocities. At the October, 1953, meeting of the Texas Gulf Coast subcommittee, a compilation of actual field reports was presented on upward annular velocities in actual use by numerous operators in this region. These showed the typical practice of very low annular velocities in very large holes, and higher velocities in smaller holes, as shown in Table 1. This is simply because of using about the same pump equipment while the same rig drills 12¼-in. hole or 9⅞-in. hole to intermediate depths, or drills 8¾-in. hole or 6-in. hole to greater depths.

The subcommittee agreed that it could now recommend that an upward annular velocity of 150 fpm or less may be found satisfactory. In many cases with a given pump horsepower, this may permit reduction of volume rate, reduction of drillpipe pressure loss, and thus more pressure available at the bit for increase in jet velocity.

Size of bit cuttings. For a discussion of the probable sizes of bit cuttings, bit research test block samples of hard dolomite cut with a relatively fresh bit at rates of penetration, weights on bit, and revolutions per minute reasonably representative of some medium drilling conditions such as 20, 10, and 4 ft per hour and 60 rpm were studied. These rates represent "average advances per revolution" of 0.067 in., 0.033 in., and 0.013 in. In one sense, this "average advance per revolution" might be considered the "average thickness" of cuttings if every portion of bottom were partially cut by some one bit tooth on **each** revolution.

However, for each of the different rates of penetration, these test block cuttings showed remarkable similarity of size distribution, and a remarkable proportion of cuttings approaching 0.100-in. thickness for much of their lenticular shape. It appears, therefore, that some spots on bottom were not being cut for several revolutions, and then suddenly yielded a cutting of thickness of from two to six times the average bit advance per revolution. (Or perhaps the sequence should be: "yielded a thick cutting then were below tooth contact level for several revolutions.")

Effect of drilling fluid. Other experiments have shown[1] that cutting of rock formations under high hydrostatic pressures and in contact with high-density, high-solids-content drilling fluids displays more of a "plastic" character than the "brittle" character evidenced on test blocks at atmospheric pressure. Thus it could be expected that cuttings from wells should be smaller than from test blocks.

Other simple calculations show very small volume percentage of cuttings in the circulating mud for all except the fastest drilling with the largest bits, or with very small mud volume rate. It appears, therefore, that any practical requirements for large upward annular velocities are more dependent upon **uncertainties of actual sizes of sloughing shale fragments,** and **uncertainties of sizes of hole enlargements in shales, both hard and soft,** than upon **bit cuttings removal.**

In other words, extremely low **calculated** annular velocities appeared to be widely acceptable except in particular cases. When the question is raised as to probable enlargements of hole diameter in various shales (hard as well as soft, (there is a puzzle as to **actual** upward velocities therein and the con-

TABLE 1. Data on upward annular velocities. (Texas Gulf Coast)

Well bore, inches	Drill-pipe OD, inches	Number of wells	Circulation rate, Gpm			Annular velocity, Fpm		
			Minimum	Average	Maximum	Minimum	Average	Maximum
15	4½	7	410	619	820	48	75	98
12¼	4½	10	250	490	712	47	93	138
9⅞	3½	1	—	295	—	—	86	—
	4	2	326	383	440	98	116	133
	4½	—	—	—	—	—	—	—
	5	2	390	485	580	124	160	197
8¾	4½	120	190	444	745	81	194	325
8¾	3½	3	255	327	410	100	129	162
	4½	33	270	454	718	123	206	325
	5	11	345	534	880	172	266	440
7⅞ & 7⅛	3½	3	238	327	420	108	159	208
	4½	5	340	382	450	200	226	266
	5	3	222	407	520	147	271	318
6 & 6¼	3½	7	130	226	340	126	220	330

sequent necessary reduction in shale-fragment sizes that must occur before being carried up through such enlargements. A similar situation may exist in air or gas drilling wherein, presumably, all sizes of bit cuttings are pulverized before they are carried out of the hole.

Obvious interest attaches to the carrying properties of the mud, both as to velocity, whether flow is laminar or turbulent, viscosity, thixotrophy, and density. Mud properties that may be unnecessarily emphasized for fragment-carrying requirements can be a serious detriment to rate of penetration, both as to inefficient bottom-cleaning properties and because of reduced circulation rate on account of greater wastage of hydraulic horsepower in flow friction in drill pipe.

Attention was directed to the theoretical analysis of the significance of viscosity of the fluid in the cleaning or sweeping of a minute particle from a smooth surface by a fluid, disregarding adhesive forces between the particle and the surface. When it is considered that the molecules, or microscopic particles, of the "fluid" immediately in contact with the smooth surface are virtually stationary and that the rate of shear, or rate of increased velocity for each minute layer farther from the surface, is dependent upon viscosity it becomes evident that the more abrupt velocity gradient of the lower-viscosity fluid contributes importantly to its moving force on thin particles, i.e., sweeping or cleaning effect.

This emphasizes the possible benefits from low-viscosity fluids above and beyond the other considerations of drill-pipe pressure drop and available volume rate and jet velocity with a limited rig pump horsepower.

Hydraulic variations. Eckel and Nolley[2] observed that, if it could be agreed that the field data taken by Humble for hydraulic variations tried with drag-bit nozzles were reasonably correct, then their mathematical analysis of those results already provides a systematic answer for many of the objectives announced by this study committee. It was pointed out that the work referred to had indicated an optimum for bit hydraulic effect when the pressure drop at the nozzles was approximately 70 per cent of the total pressure available from the pump.

With this relation, a relatively direct procedure may be followed to calculate the proper sizes of nozzles for all bits to be used by a given rig for a given mud program and hole-size and drill-pipe program on the basis of keeping the pumps loaded to a given hydraulic horsepower. The tool pusher then can be given a small card with the jet program.

The foregoing is based on the theory that the benefits of jet action are related to "impact effect" which, in turn, is proportional to volume rate times velocity (QV). There ensued considerable discussion as to whether the benefits might not be related to hydraulic horsepower, which is proportional to volume rate times velocity squared (QV^2). If the latter is true, there should be notable benefits from higher nozzle velocities and low volume rates.

For example, with 375 hydraulic horsepower at the pump and 7000 ft of 4½-in. drill pipe, the following comparison might be made between: a, a given liner size delivering 530 gpm at full rating; or b, reducing speed to deliver only 450 gpm so as to reduce drill-pipe friction and permit more of the available pressure for velocity at the jets; or c, changing liners to give the same latter 450 gpm, but with more total pressure, and thus still more pressure and velocity at the jets.

Liner size, inches	6¾	6¼	
Rated psi	1225	1435	
Case	a	b	c
Gallons per minute	530	450	450
Psi available for jets	410	635	845
Theoretical jet hydraulic horsepower	220	275	315
Increase QV, per cent	Reference	0	71
Increase jet hydraulic horsepower, per cent	Reference	31	75

It would appear that where drilling conditions can be assumed to be nearly uniform, it should be possible readily to determine whether changes in rate of penetration with changes in hydraulic conditions compare more closely with changes in QV or with changes in QV^2.

In all of the discussion of the foregoing, it was generally accepted that there are limitations on one extreme due to excessive velocities and uneconomic erosion of nozzles, and on the other extreme due to minimum practical upward annular velocity dictated by local experience.

A fairly good distribution of the jet-bit record forms had been made and a considerable number of records were turned in to the Texas Gulf Coast Subcommittee. However, because of the many variables, there were relatively few situations where constructive comparisons could be drawn.

It would be desirable to have for comparison data on several wells in a given field drilled by the same rig and crews, with the same hole size and mud programs, and with variations only in hydraulics at the bit, weight on bit, and, possibly, variations in rotary revolutions per minute. This virtually implies a planned experiment in an active field-development program by one company, or a well-organized cooperative effort between various operating companies and drilling contractors in such a field development.

A field development with a fairly good spread of jet hydraulics was reported from Red Fish Bay field, Nueces County, Texas, and a more limited one from Helen Gohlke field, Dewitt County, Texas. It appeared from the data from Helen Gohlke field that jet velocities beyond 300-ft per second seemed of no advantage for the drilling conditions reported below 6000-ft, but there was a limited range of weight on bit involved.

Horsepower vs penetration rate. For the Red Fish Bay field data, a very interesting observation was made. It was observed that there appears to be what has since been referred to as an "S-curve" relationship between hydraulic horsepower at the bit and rate of penetration (Fig. 1). This was noted by plotting averages of various groups of data that were considered to be related as to depth and probable hardness, and finding that the low values of hydraulic horsepower, there was relatively little improvement of rate of penetration with increase of hydraulic horsepower. For an intermediate range, however, there were very good increases in rates of penetration associated with moderate increases of bit hydraulic horsepower. Then again, at the highest rates of penetration relatively small increases in rate of penetration were associated with increased hydraulic horsepower.

Explanation of this may be that at low hydraulic power applications, there is not much bottom cleaning being accomplished by the jets anyway. There-

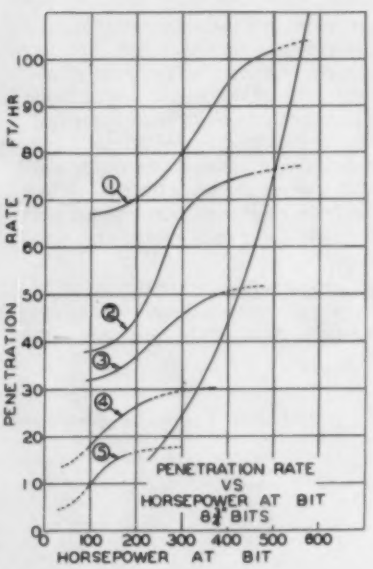

FIG. 1. **S-Curve relationship** between hydraulic horsepower at the bit and rate of penetration based on data obtained in the Red Fish Bay field of Chambers County, Texas.

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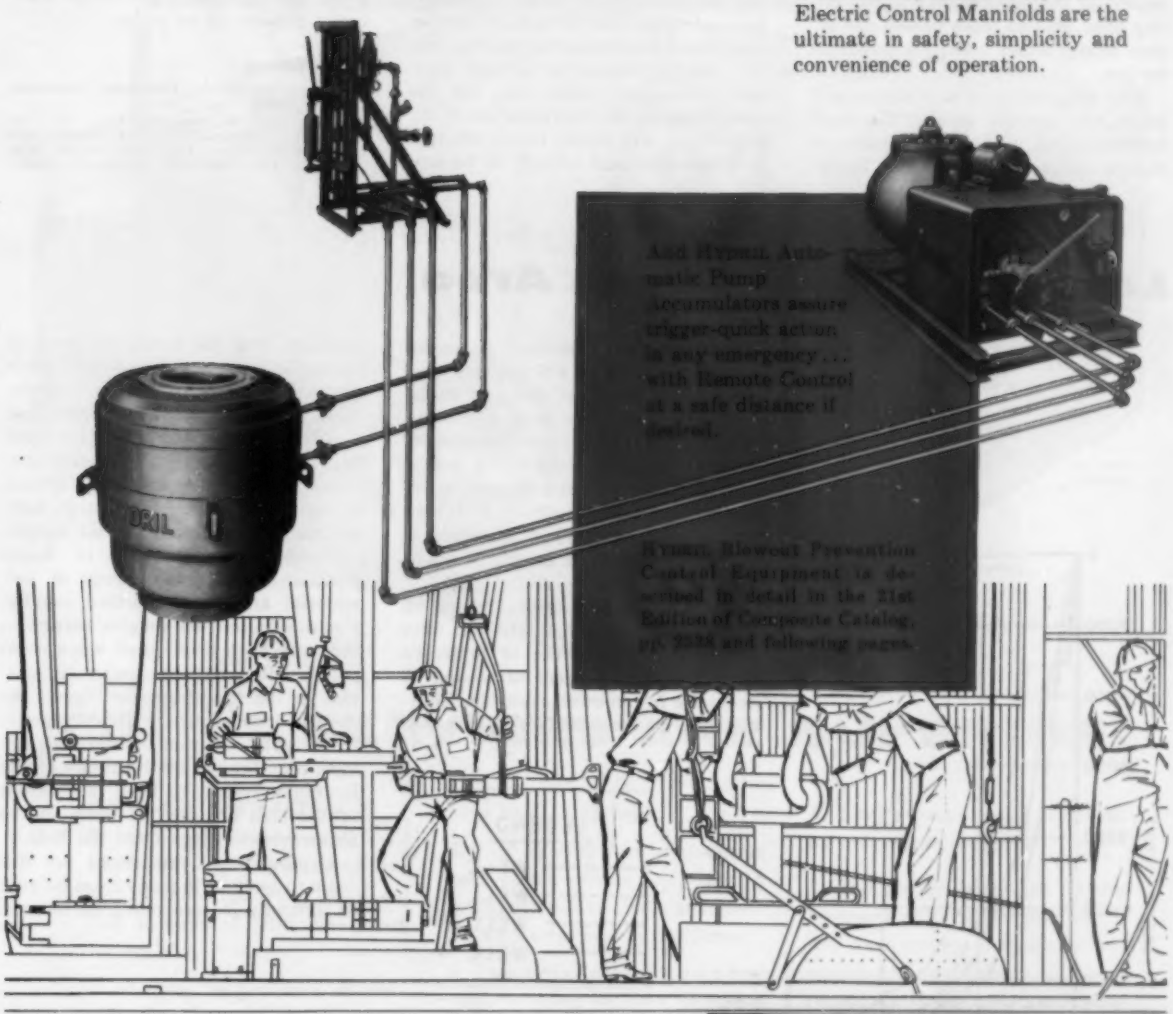
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fore, there is not much difference between the little benefit of one low jet velocity and the little benefit of another slightly higher jet velocity. At certain intermediate jet velocities and volume rates, however, there begins to be some cleaning of bottom between the successive bit-tooth impacts at a given spot and this removal of crushed, but adhering, fragments is improved with increased hydraulic power application. Thus notable increases of rate of penetration are accomplished with moderate increases of jet action. At some higher hydraulic values, however, nearly all the possible cleaning is getting done, and no more benefit can accrue from further hydraulic power of the jets.

This approach to an explanation may be equally suitable whether the trend toward higher rates of penetration is due to softer formation or to higher weight on the bit. In either case more formation is being broken by each bit tooth, there is more cleaning to be done, thus there is a certain range in which more cleaning (more jet action) contributes to faster drilling.

It is believed that this relation should be demonstrable by selecting a situation where the rate of penetration can be expected to be fairly uniform and then carefully observing if rate of penetration can be varied by changing only the circulation rate such as by changing pump speed or changing from one size pump to another, or by changing combinations of pumps if arrangement of equipment permits. In such an experiment the changed circulation rate will greatly change the surface pressure, drill-pipe friction, etc., but the main thing for the interpretation of the experiment will simply be the changes in volume rate and velocity of the jets.

Trend to more pump horsepower. Since the start of this Jet-bit Study Committee, there has been a remarkable increase in application of hydraulic horsepower in drilling. Larger pumps have become popular, even though their application becomes restricted when deep holes require small drill pipe and heavy mud. Much higher pressures are being tried and used than would have been considered practical just a few years ago. More attention has been directed to hydraulic efficiency of drill string, and mechanical efficiency of pump drives, so as to permit the maximum delivery of jet power.

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1. Cunningham, R. A.: *Petroleum Technology*, Nov. (1955).
2. Eckel, John R., and Nolley, J. P.: An Analysis of Hydraulic Factors Affecting Rate of Penetration of Drag-Type Rotary Bits, *Drilling and Production Practice*, 9 (1949).

Louisiana Gulf Coast Area

W. D. Clift

Humble Oil & Refining Company
New Orleans, Louisiana

Drilling rates attained have increased in excess of 100 per cent during a 3-year period in one field in the Louisiana Gulf Coast area as a result of an increase in hydraulic horsepower utilized and an increase in bit weight carried. Data provided do not represent an economic limit of hydraulic horsepower and bit weight inasmuch as further increases are currently resulting in higher drilling rates.

Drilling rates improved. During the recent past improved drilling rates have resulted from use of increased bit weight and efficient utilization of hydraulic horsepower available. Information obtained in the West Texas area indicates that the economic limit of hydraulic horsepower may have been reached when drilling the hard formations. However, in the Louisiana Gulf Coast area, the economic limit has not been reached, as drilling rates are continuing to improve when the drilling procedures include increases in both hydraulic horsepower and bit weight.

Formations penetrated in South Louisiana are predominantly of soft material and can be drilled rapidly. For this reason, bit weights carried in this area have been small when compared with those conventionally carried in the hard-formation areas. As the soft formations are drilled rapidly, bit weights and resultant drilling rates have been limited by the ability of the hydraulic system to keep the bottom of the hole and the bit clean and to remove bit cuttings from the hole.

Drilling-time comparisons are difficult to evaluate in many cases because of difficulty in controlling the numer-

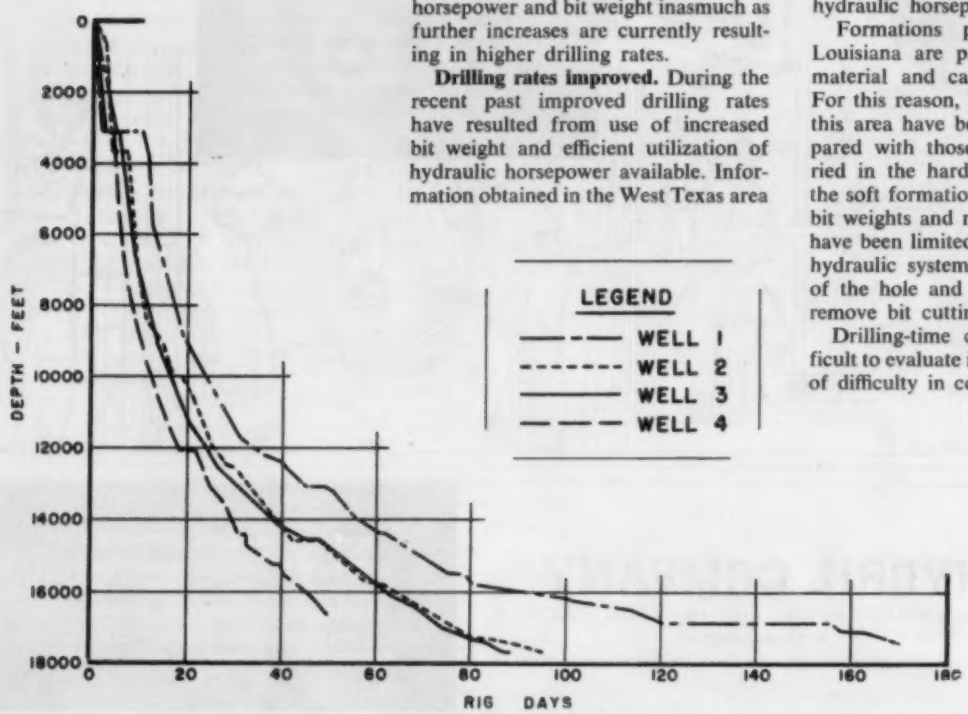
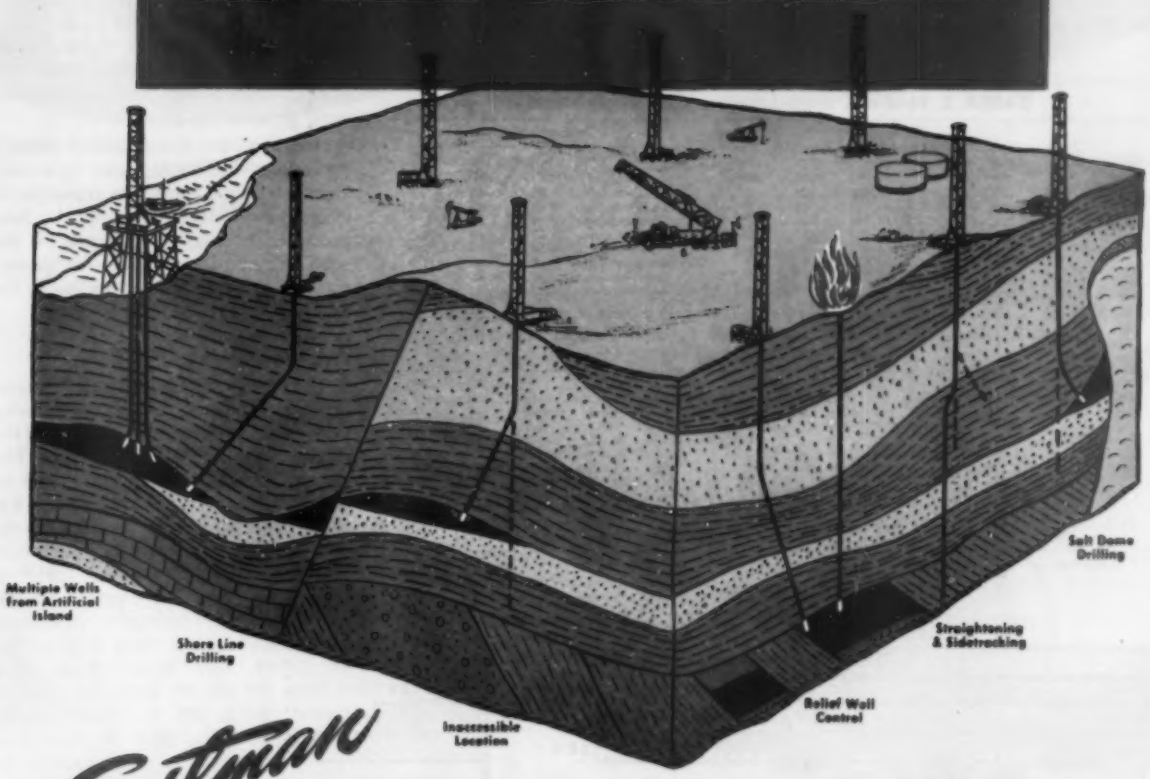


FIG. 2. **Drilling time curves** showing well depth versus rig days for four wells drilled in same South Louisiana field.

DIRECTIONAL DRILLING...?

SIDETRACKING...?

OIL WELL SURVEYING...?



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ous variables which influence drilling performance. Thus, some tests carried on with one or more of the drilling practices changed may have been inconclusive. Data, however, are available from a South Louisiana field where valid drilling-performance comparisons can be made.

Fig. 2 is a drilling-time curve in which depth versus rig days is plotted for four field wells located in the same field and drilled with comparable practices during a three-year period. It will be noted that drilling time to approximately 17,000 ft has been reduced by greater than 50 per cent since the drilling of Well 1. Table 2 carries pertinent well data for these four wells which are listed in the order drilled. Hole sizes drilled, depth intervals penetrated, and drilling fluids carried are such that drilling performance comparisons are possible.

Table 3 shows data concerning drilling practices followed such as drill-pipe size used, number and size of drill collars run, bit weights carried, circulating pressures maintained, and hydraulic horsepower developed. The influence of bit weight and hydraulic horsepower is illustrated in Fig. 3, Comparisons of drilling performance attained are shown for the 12¼-in. holes and for the 8⅝-in. holes. Drilling rates increased slightly in excess of 100 per cent for both hole sizes from Well No. 1 to Well No. 4 as a result of: 1, an increase in hydraulic horsepower utilized which permitted satisfactory cleaning of the bottom of the hole and the bit; and 2, an increase in bit weights carried. A review of all wells illustrated indicates that the highest drilling rate was attained when both hydraulic horsepower and bit weights were greatest.

It is apparent from current drilling operations where still higher hydraulic horsepower and further increases in bit weight are being utilized that the data presented herein do not represent the economic limit of hydraulic horsepower and bit weight for drilling in the South Louisiana Gulf Coast area.

TABLE 2. Field-well drilling programs. (South Louisiana)

Well name	Total depth -ft	Hole size -in.	Depth interval-ft From	Depth interval-ft To	Rotary speed -rpm	Maximum drift angle -degrees	Drilling fluid Type	Weight -lb/gal	Visc. -sec	W. L. -cc
No. 1	17,403	12¼	3,060	13,053	100	3	Alk-tan oil-emulsion	10.4	45	8.0
		8⅝	13,053	16,822	85	3¾	Alk-tan oil-emulsion	10.3	45	4.5
No. 2	17,637	12¼	3,550	14,525	150	2½	Alk-tan oil-emulsion	9.9	43	7.6
		8⅝	14,525	17,637	110	2¼	Alk-tan oil-emulsion	10.4	49	5.8
No. 3	17,617	12¼	3,050	14,557	100	1½	Alk-tan oil-emulsion	10.0	45	9.0
		8⅝	14,557	17,617	90	5	Alk-tan oil-emulsion	9.8	47	11.7
No. 4	16,906	12¼	3,030	12,020	110	2¼	Alk-tan oil-emulsion	9.8	45	12.5
		8⅝	12,020	16,906	90	4¾	Alk-tan oil-emulsion	9.9	41	9.1

TABLE 3. Effect of bit weight and hydraulic horsepower field-well drilling (South Louisiana)

Well name	Hole size-in.	Depth interval-ft From	Depth interval-ft To	No. bits used	Drilling rate-ft/hr rotated	Drill pipe size-in.	Drill collars No.	Drill collars Size-in.	Maximum bit wt. -lb	Circ. pressure-psi	Hydraulic horsepower Total	Hydraulic horsepower At bit
No. 1	12¼	3,060	13,053	30	18.7	5	5	7¾	20,000	1,700	505*	160
	8⅝	13,053	16,822	49	5.2	4 & 5	5	6½	20,000	1,800	325†	50†
No. 2	12¼	3,550	14,525	36	24.2	5	5	7¾	20,000	2,500	1020*	480
	8⅝	14,525	17,637	43	5.7	4 & 5	6	6⅝	12,000	2,500	576†	134†
No. 3	12¼	3,050	14,557	37	22.6	5	8	7¾	20,000	2,500	1015*	540
	8⅝	14,557	17,617	38	7.7	5	11	6½	15,000	2,500	525†	225†
No. 4	12¼	3,030	12,020	16	38.4	5	11	7¾	30,000	2,800	905*	711
	8⅝	12,020	16,906	32	12.1	4 & 5	14	6½	20,000	2,800	711†	218†

* 11,500 feet. † 16,500 feet.

Acknowledgments

The author wishes to thank the management of Humble Oil & Refining Company for permission to publish the data presented in this paper. The author also acknowledges the work of R. G. McGlamery, Humble Oil & Refining Company, who assisted in the compilation and evaluation of these data. ★ ★ ★

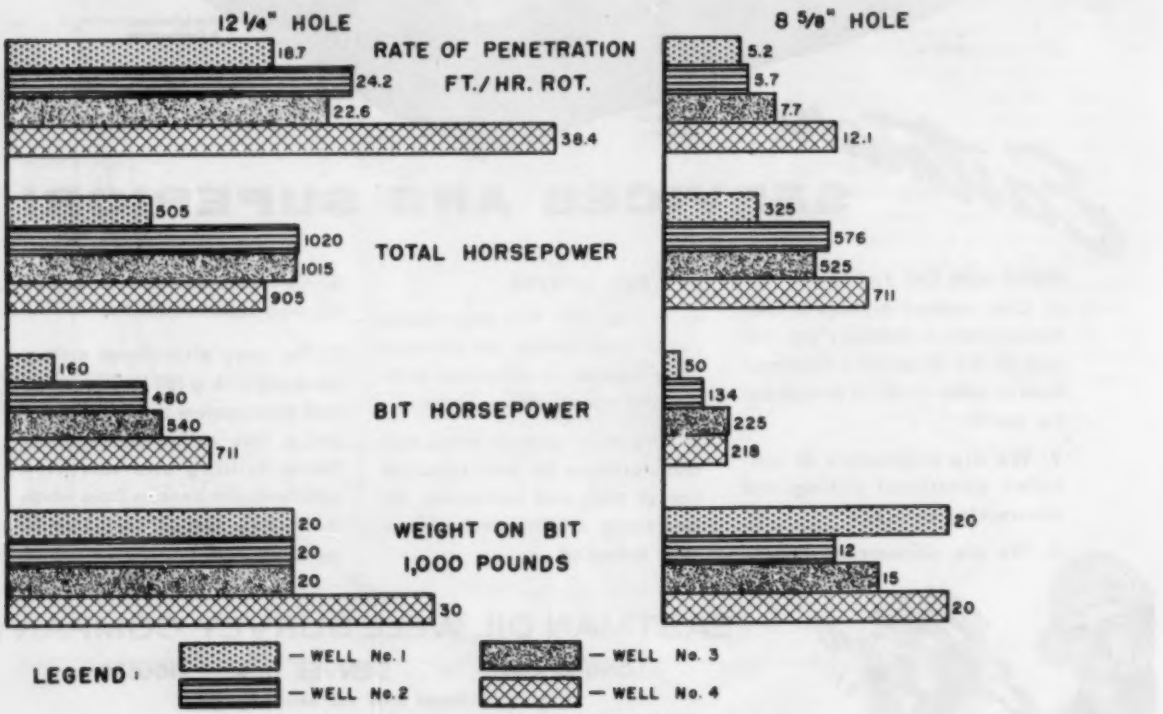
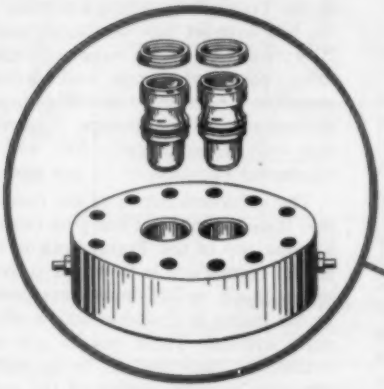
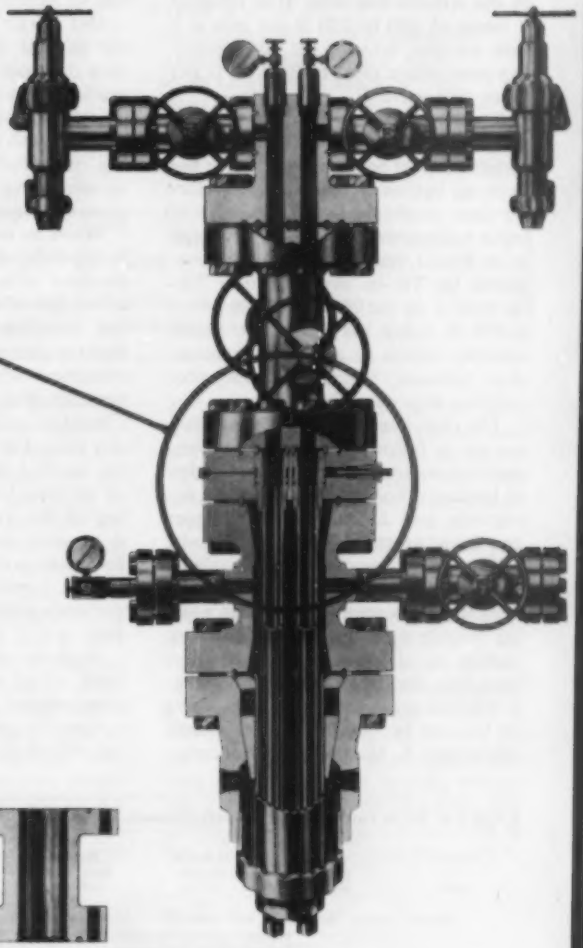


FIG. 3. **Effect of bit weight and hydraulic horsepower** on drilling rate in South Louisiana.

RECTOR Dual-String Hanger Flange

Outstanding Simplicity and Flexibility, plus the FAMOUS Rector Metal-to-Metal Seal





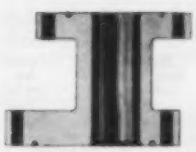
SIMPLICITY: The flange has two full opening tapered bores in which the strings are suspended by threaded mandrels. This eliminates mating and sealing two tubing hangers in a single, large bore. Each string can be suspended, temporarily sealed, and held down independently of the other assuring maximum ease of installation with complete control of well.

FLEXIBILITY: Regular 2" API upset tubing can be run or pulled through the bores in the flange.

METAL-to-METAL SEALS: Each mandrel is independently sealed by a metal seal ring in the groove at the junction of mandrel and flange. This metal-to-metal sealing arrangement also acts as a hold-down. "O" Rings on the mandrel provide a temporary seal during completion and permit testing the seal after Christmas Tree is installed. Mandrels are grooved for hold-down locking screws, which are optional in the flange.

- **Rector Dual-String Hanger Flanges are available in Nom 6 and Nom 8 sizes in any series. Mandrels are interchangeable.**

For maximum simplicity and flexibility of dual-string suspension, plus the metal-to-metal seal that never requires maintenance or replacement, specify a Rector Dual-String Hanger Flange in your dual completion Christmas Tree.



Off-Set Adapter Spool permits use of regular preventer equipment with alignment directly over each individual bore while running and pulling tubing. After first string is run, Adapter Spool can be rotated to center directly over the other bore.

25

RECTOR WELL EQUIPMENT COMPANY INC

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Ark-La-Tex Area

John Cutrer
Reed Roller Bit Company
Shreveport, Louisiana

This is a summary report on jet-bit drilling by the Ark-La-Tex subcommittee covering the period 1952 through 1955. Detailed data are given on 21 wells in the Athens, Louisiana, field, 9 wells in the Malakoff, Texas, field and 4 wells in the Woodlawn, Texas, field. Jet-bit drilling has substantially reduced the cost of drilling in the Ark-La-Tex area. It is believed a range of 100 to 150 ft per min is a safe annular velocity for corresponding penetration rates of 3 to 50 ft per hour, respectively.

Results indicate a minimum nozzle velocity of 190 to 200 ft per sec for satisfactory jet performance. There has been no optimum upper nozzle-velocity limit established. By utilizing 115 input horsepower for 4½-in. drill pipe in an 8¾-in. hole and 146 input horsepower for 3½-in. drill pipe in a 7⅞-in. hole, a rig can jet drill to a depth of 6,500 ft using the minimum nozzle velocity. There is a definite relationship between hydraulic horsepower and rate of penetration.

The objectives of this study committee are as follows: 1. Develop recommendations for the proper application of hydraulic horsepower in drilling operations, and 2. Determine the upper and lower practical limits of hydraulic horsepower as applied to jet drilling.

In order to accomplish the objectives the subcommittee has been seeking reliable data and developing information on all phases of the problem including the items listed following: 1. Various areas and formations where jet bits can be used with an economic advantage; 2. Minimum safe annular-velocity requirement for practical operation of jet bits; 3. Minimum nozzle-velocity requirement for practical operation of jet bits; 4. Maximum nozzle-velocity requirement for practical operation of jet bits; 5. Minimum hydraulic-horsepower requirement for jet-bit operation; and 6. Relationship between hydraulic horsepower and rate of penetration.

Our major obstacle has been that the general accumulation of drilling data does not provide adequate information from which to resolve all our objectives; and because of the scattered drilling with little concentrated drilling, our efforts have been restricted in accumulating reliable data which is generally acceptable.

When to use jet bits. It is generally acknowledged that the jet bit can be credited with a substantial reduction in the cost of drilling in this area. Present information, however, indicates that the principal part of the benefit is obtained when drilling formations younger than the Travis Peak section (Hosston formation of lower Cretaceous age). For this reason, the committee made a study of the performance of jet bits, both above and below the top of the Travis Peak section. Table 4 presents data regarding jet-bit performance in the Athens field, Claiborne Parish, Louisiana, as compared to the previous performance of conventional bits.

A study of 21 wells in the Athens field, 10 of which used 100 per cent conventional bits and 11 of which used principally jet bits, showed that for the interval 0 to 7500 ft a reduction of 36.2 per cent in the number of bits and 16 per cent in the rotating hours was affected.

Table 5 represents data on only Travis Peak drilling in the same wells and shows an overall improvement of approximately 15.8 per cent reduction in number of bits and 2 per cent reduction in rotating hours, on these sections of the Travis Peak where a portion of the bits were jet bits. Of the 21 wells, 20 were drilled by the same contractor using comparable rigs and drilling practices. Average available input horsepower to the pumps, however, was only approximately 230 with a maximum variation of 15 per cent.

The subcommittee is of the opinion that the economics of using jet bits below the top of the Travis Peak in the harder formations is favorable providing as much as 225 input horsepower to the pump is available and is efficiently applied. These results are not necessarily presented as being representative because studies of the same section in other fields indicate widely varying degrees of improvement in drilling the deeper and harder formations. This is possibly due to different operators' drilling practices and different distribution of the varying amounts of horsepower in their hydraulic systems.

Minimum annular velocities. The investigation has revealed that there are many records of economically drilled wells where the annular velocity ranged from 100 to 150 ft per min with a few wells using less than 100 ft per min without any apparent adverse effects. Data analysed to date indicates that a range of 100 to 150 ft per min is a safe annular-return velocity in this area for corresponding drilling rates of 3 to 50 ft per hour. With the introduction of jet bits, the volume of fluid circulated was reduced and the pressure increased. Lowering the annular-return velocity from the previously accepted minimum safe return velocities of 175 to 180 ft per min to 100 to 150 ft per min has allowed many contractors who were not able to run jet bits because inadequate hydraulic horsepower to run jet bits by re-distributing the available horsepower in the hydraulic system.

Fig. 4 (a representative group of wells) has been prepared to present a graphical representation of average maximum and minimum annular velo-

TABLE 4. Jet vs conventional bit performance. (Athens field, Claiborne Parish, Louisiana)

Hole size: 8¾ in.—9 in. Interval: 0—7500 ft

Number of wells	Average per cent jets run	Average number of bits	Average Total hours rotating	Average feet per bit	Average hours per bit
10	0	47	771	160	16.4
11	81	30	648	250	21.6
		Per cent reduction in number of bits		—36.2.	
		Per cent reduction in rotating hours		—16.0.	

NOTE: Drilling practices, size rig, and available pump input horsepower were essentially the same.

TABLE 5. Jet vs conventional bit performance in Travis Peak. (Athens field, Claiborne Parish, Louisiana)

Hole size: 8¾ in.—9 in. Average interval: 7500 ft—8114 ft (614 ft) Jets
7500 ft—8266 ft (766 ft) Conv.

Number of wells	Average per cent jet run	Average feet per bit	Rotating hours per 100 ft	Bits per 100 ft	Average hours per bit
8	48.6	46.8	28.3	2.134	13.2
12	0	43.8	28.9	2.537	12.6
		Per cent reduction in number of bits		—15.8.	
		Per cent reduction in rotating hours		— 2.0.	

NOTE: Drilling practices, size rig, and available pump input horsepower were essentially the same.

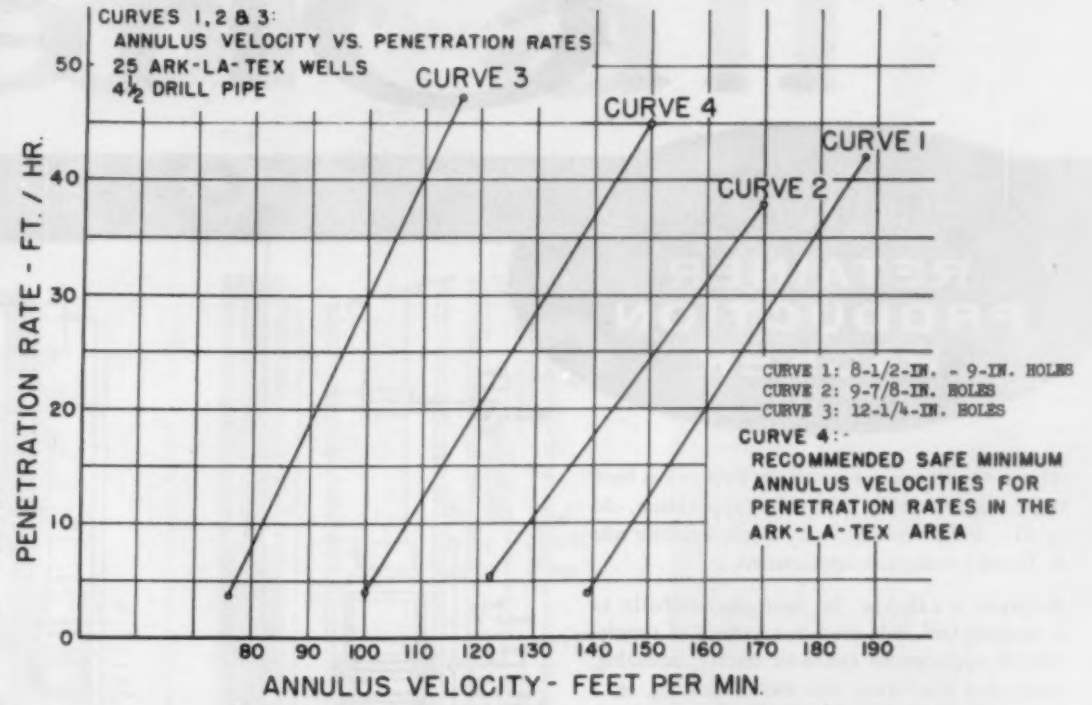

FIG. 4. **Average maximum and minimum annular velocities** and corresponding average rates of penetration for a representative group of wells in the Ark-La-Tex area.

cities and their corresponding average penetration rates. Curves 1, 2, and 3 represent 8½-in. to 9-in., 9⅞-in., and 12¼-in. holes, respectively using 4½-in. drill pipe. Curve 4 is a hypothetical curve based on the opinions of this subcommittee in an attempt to establish a required return-velocity relationship relative to penetration rates encountered. Considering the normal hole problems prevailing in this area, it is believed a return velocity of 100 ft per min for low penetration rates of 3 to 5 ft per hour and 150 ft per min for penetration rates of 40 to 50 ft per hour is adequate.

Minimum nozzle velocity. A study of the accumulated data indicates that 190 to 200 ft per sec nozzle velocity is more adaptable for this area to subsequently show a substantial improvement in bit performance. Table 6 shows tabulated data on 9 wells drilled in the Malakoff, Texas, field by 5 contractors — all using essentially the same bit program, drilling weights, mud program, rotary speed, and drill pipe.

Wells A, B, C, and D were drilled by four different contractors; wells E, F, G, H, and J were drilled by the same contractor with two different rigs. Wells E and F were drilled with the same steam rig with an 18-in. pump with 7¼-in. liners. Wells G, H, and J were drilled with the same steam rig with a 20-in. pump with 7¼-in. liners. The full pump capacity was not used on well G because of a bad string of drill pipe. One hundred sixty-five feet per second nozzle velocity was used on well D, using 11.1 per cent more bits than used on well C which ran all regular bits, and only a reduction of 18.6 per cent in rotating hours.

By increasing the nozzle velocity to 190 ft per sec on wells E and F there was a reduction of 12.5 per cent in the number of bits and a reduction of 3.9 per cent in rotating hours over well D using 165 ft per sec. On well G, using 200 ft per sec nozzle velocity, there was no reduction in the number of bits used but there was a reduction of 8.9 per cent in rotating hours over wells E and F. It is interesting to note that well B, running 100 per cent jet bits, using a nozzle velocity of 135 ft per sec used 4 bits more than were used on well C running 100 per cent regular bits with practically the same number of rotating hours.

Maximum nozzle velocity. It is generally acknowledged that the information gathered to date will not support the determination of a value for a maximum practical nozzle velocity. From the data in Table 6, however, we believe that we may be approaching the maximum practical nozzle velocity at 257 ft per sec. On well H the full capacity of the 20-in. steam pump was used with three ½-in. nozzles obtaining a nozzle velocity of 223 ft per sec, giving a reduction of 5.9 per cent in bits used and 9.4 per cent reduction in

TABLE 6. Analysis of Nine Wells Drilled in the Malakoff, field, Texas.

	Hole size: 8¾ in.		Average interval: 0—7500 ft						
Well:	A	B	C	D	E	F	G	H	J
Number bits	2-J 19R	22J	18R	20J	18J	17J	17J	16J	18J
Rotating hours	561	529	532	433	421	413	380	344	325
Average feet per bit	321	310	382	346	377	400	400	423	446
Average bit life, hours	26.7	24.0	29.6	21.7	23.4	24.3	22.4	21.5	21.6
Average penetration rate, feet per hour	12.0	12.8	12.9	15.9	16.1	16.2	17.9	19.6	20.6
Average circulation rate, gal. per minute	355	310	350	375	350	350	370	400	360
Average nozzle velocity, feet per second	152	135	105	165	190	190	200	223	257
Average hhp expended at bit	30	29	29	51	67	67	83	100	123
Average pump hhp	127	108	97	163	162	162	180	244	24
Ratio bit hhp to pump hhp	237	268	299	312	413	413	455	410	506
Orifice area in jets, Square inches	1.1 0.746	0. [illegible]	1.1	0.746	0.589	0.589	0.589	0.589	0.450

Wells E and F drilled with same rig with 18 in. a[illegible] pump with 7¼ in. liners.
Wells G, H, and J drilled with same rig with 20-in steam pump with 7¼ in. liners.
hhp—Hydraulic horsepower. R—Regular bits. J—Jet bits.

...One

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SINGLE ZONE

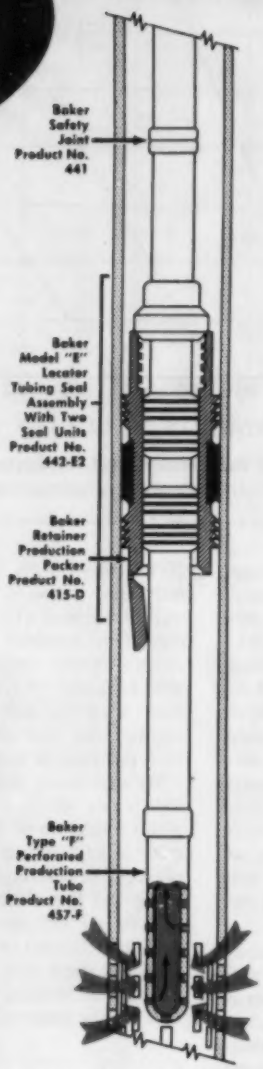
PERMANENT-TYPE WELL COMPLETIONS

RETAINER PRODUCTION PACKER

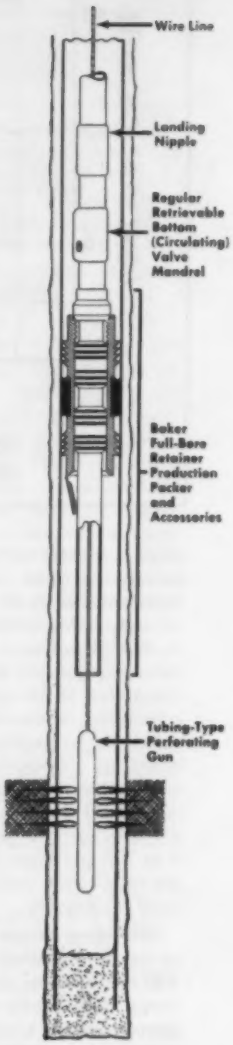
PRODUCT NO. 415-D

The Baker Retainer Production Packer has been used in nearly every production application, old or new, and promises to play an even greater role in future production applications.

Because it can also be used successfully as a squeeze tool, it is used in a variety of supplemental applications (such as testing, acidizing, formation fracturing, squeeze cementing, etc.) that might be required during the completion or work-over phase of a well. That is why the Baker Retainer Production Packer has been frequently referred to as the "universal" packer, because it is truly the *one* packer that can be used *for all* production and many supplemental applications.


Baker Safety Joint Product No. 441
Baker Model "E" Locator Tubing Seal Assembly With Two Seal Units Product No. 442-E2
Baker Retainer Production Packer Product No. 415-D
Baker Type "F" Perforated Production Tube Product No. 457-F

Illustrates Packer set in casing with Locator Tubing Seal Assembly and Production Tube installed for single zone production.


Wire Line
Landing Nipple
Regular Retrievable Bottom (Circulating) Valve Mandrel
Baker Full-Bore Retainer Production Packer and Accessories
Tubing-Type Perforating Gun

Illustrates typical Permanent-Type Well Completion Hook-Up showing perforating operation through and below the Packer.

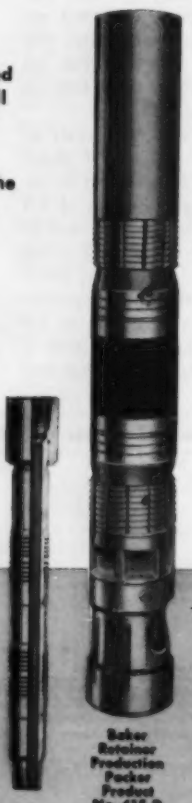
FEATURES

Can be run and set with the speed and accuracy of wire line, as well as on tubing or drill pipe.

Holds any pressure from either above or below that is safe for the casing, even under temperatures in excess of 300°F.

Pack-off is independent of set-down weight or tension. Tubing string is free; just pick up (or unlatch and pick up) to remove it.

When tubing is removed, flapper valve closes to isolate zone below packer.



Baker Locator Tubing Seal Assembly Product No. 442-E2

Baker Retainer Production Packer Product No. 415-D

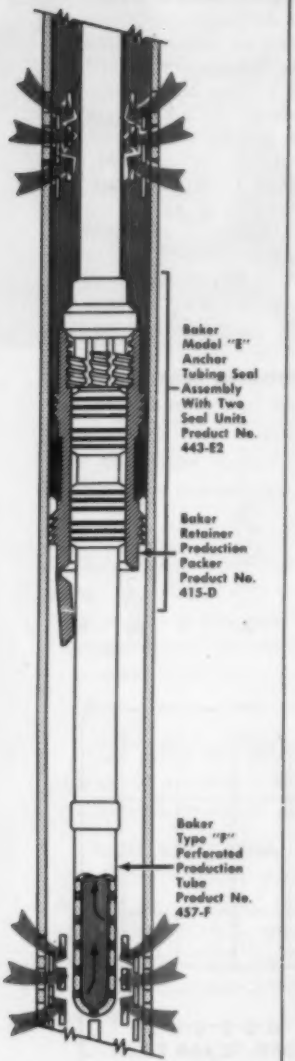
Successfully holds high pressures from above or below

... at shallow or record depths
even under temperatures in excess of 300°F.

for all

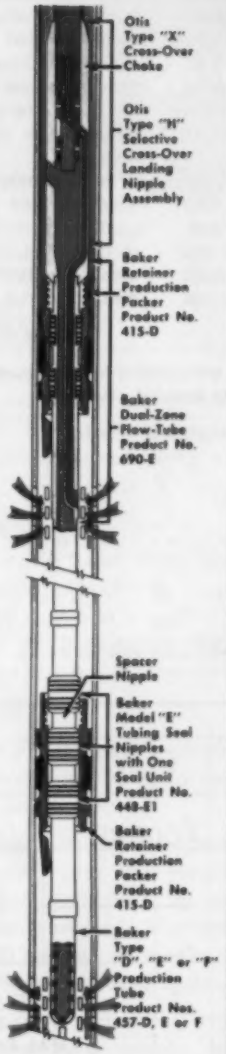
DUAL ZONE

SINGLE PACKER


Baker Model "E" Anchor Tubing Seal Assembly With Two Seal Units Product No. 443-E2
Baker Retainer Production Packer Product No. 415-D
Baker Type "F" Perforated Production Tube Product No. 457-F

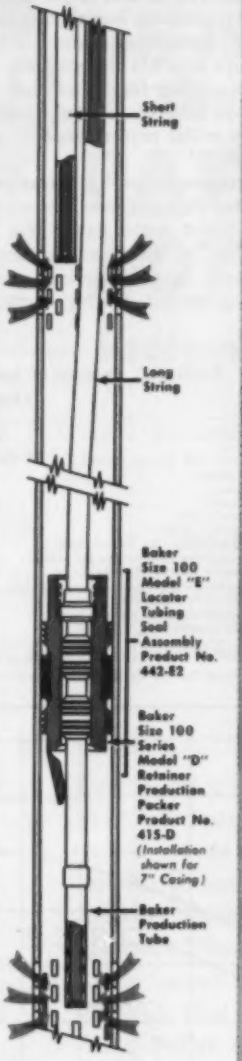
Illustrates Packer set in casing, with anchored production string for dual zone production. Tubing can be released from packer by rotating to right.

SELECTIVE CROSS-OVER


Otis Type "X" Cross-Over Choke
Otis Type "H" Selective Cross-Over Landing Nipple Assembly
Baker Retainer Production Packer Product No. 415-D
Baker Dual-Zone Flow-Tube Product No. 690-E
Spacer Nipple
Baker Model "E" Tubing Seal Nipples with One Seal Unit Product No. 448-E1
Baker Retainer Production Packer Product No. 415-D
Baker Type "D", "E" or "F" Production Tube Product Nos. 457-D, E or F

Illustrates selective two packer dual zone production hook-up (Baker-Otis) with Cross-over Choke installed. Flow pattern can be switched with Parallel Flow Choke.

PARALLEL STRING


Short String
Long String
Baker Size 100 Model "E" Locator Tubing Seal Assembly Product No. 442-E2
Baker Size 100 Series Model "D" Retainer Production Packer Product No. 415-D (Installation shown for 7" Casing)
Baker Production Tube

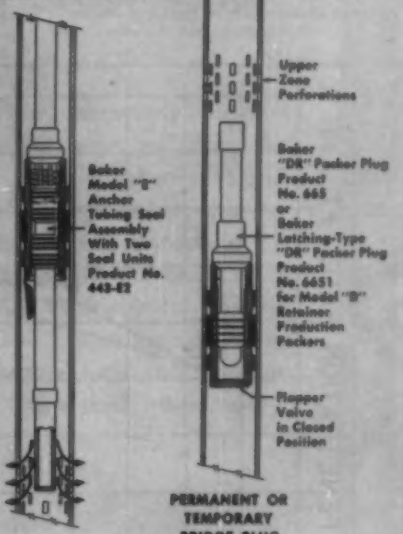
Illustrates simplest type of parallel string installation. Other installations involving two packers with full-opening tubing running through and below lower packer available.

SUPPLEMENTAL APPLICATIONS

WATER OR GAS INJECTION

The Baker Retainer Production Packer contains features that permit it to be used as a squeeze or testing tool as well as a temporary or permanent bridge plug. It is thus used in a variety of supplemental applications such as gas or water injection, testing, fracturing, acidizing, etc., that may be required either during the completion phase of a well or during a later phase.

FRACTURE, ACIDIZE SWAB-TEST OR SQUEEZE CEMENTING


Baker Model "E" Anchor Tubing Seal Assembly With Two Seal Units Product No. 443-E2
Upper Zone Perforations
Baker "DR" Packer Plug Product No. 665 or Baker Latching-Type "DR" Packer Plug Product No. 6651 for Model "D" Retainer Production Packers
Flapper Valve in Closed Position

PERMANENT OR TEMPORARY BRIDGE PLUG

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rotating hours over well G using 200 ft per sec. The nozzle velocity on well J was increased to 257 ft per sec by decreasing the nozzle size from ½ in to 7/16 in., giving a reduction of only 6.2 per cent in bits used and 5.8 per cent reduction in rotating hours. The curve seems to be leveling off after passing 223 ft per sec nozzle velocity (Fig. 5 curve 1).

Minimum hydraulic horsepower. This objective has been considered with the purpose of attempting to establish a minimum input-horsepower requirement to allow the practical use of jet-type bit. To analyze this problem the following data were compiled to give an indication of the input-horsepower requirement to be available to the pumping equipment when drilling a 6500-ft well. Assuming:

Minimum nozzle velocity ..... 200 ft per min
Minimum annular velocity ..... 100 ft per min
Mud weight ..... 10 lb per gal
Three 6¼-in. OD by 2¼-in. ID by 30-ft drill collars.

	Pipe size and hole size		
	4½" FH VS 8¾"	3½" IF VS 7⅞"	3½" IF VS 8¾"
GPM to provide 100 ft per min annular velocity	230	200	260
Approx. total orifice area to furnish 200 ft per sec nozzle velocity	0.390	0.330	0.440
Calculated pressure losses to 6500 ft	655	955	1215
Hydraulic-horsepower requirements	88	112	184
Input-horsepower requirement for pump	115	146	240

Note: Horsepower-requirement calculations based on 90 per cent pump efficiency and 85 per cent engine efficiency.

The input-horsepower requirements noted, with respect to the combinations of pipe size and hole size, are comparable to those observed in instances of actual practice where satisfactory jet-bit performance was apparently being obtained with lower jet velocities as limited to the available standard size jets for these bit sizes. It is believed, however, with proper selection of nozzle sizes to maintain the optimum minimum of 190 to 200 ft per sec nozzle velocity, available horsepower to pump of 115 input horsepower for 4½-in. drill pipe in a 8¾-in. hole and 146 input horsepower for 3½-in. drill pipe in a 7⅞-in. hole is a near minimum satisfactory jet-bit performance to a depth of 6500 ft.

Horsepower and penetration. The tabulated data in Table 7 represent four wells drilled in the East Texas Woodlawn field by the same contractor and personnel, using essentially the same rated equipment, drilling practices, and mud-weight characteristics. The results in this table tend to indicate an increase in penetration rates may be expected both for an increase in pump hydraulic horsepower and an increase in the ratio of bit hydraulic horsepower to pump hydraulic horsepower (Fig. 5, curve 2).

This is also indicated in the results of the nine wells in Table 3 drilled in the Malakoff field (Fig. 5, curve 1). A major contractor in East Texas replaced a 350-hp pump with a 600-hp pump; and after drilling 12 wells, the data indicated that an increase in the average hydraulic horsepower of 28.5 per cent results in a 23 per cent increase in penetration rate and a 22.5 per cent reduction in the number of rotating hours.

Some conclusions. 1. It is generally acknowledged that the jet bit can be credited with a substantial reduction in cost of drilling in the Ark-La-Tex area. Seventy-five to 80 per cent of all rock bits run in this area in sizes

TABLE 7. Analysis of four wells drilled in the Woodlawn field, Texas. Average Interval : 0-6600 ft

Average interval: 0—6600 ft				
Wells:	A	B	C	D
Hole size, inches	8¾	9	9	9
Number bits	20	16.6	19	14.3
Rotating hours	510	472	461	405
Average feet per bit	330	396	347	460
Average bit life, hours	24	28.6	22.7	31.6
Average penetration rate, feet per hour	12.9	14.0	14.3	16.3
Average circulation rate, gallons per minute	245	352	358	382
Average nozzle velocity, feet per second	187	191	197	211
Average hydraulic horsepower expended at bit	64	68	71	86
Average pump hydraulic horsepower	169	174	161	194
Ratio bit hydraulic horsepower to pump hydraulic horsepower	378	391	441	443

NOTE: Wells A and B drilled with same rig and wells C and D drilled with same rig.

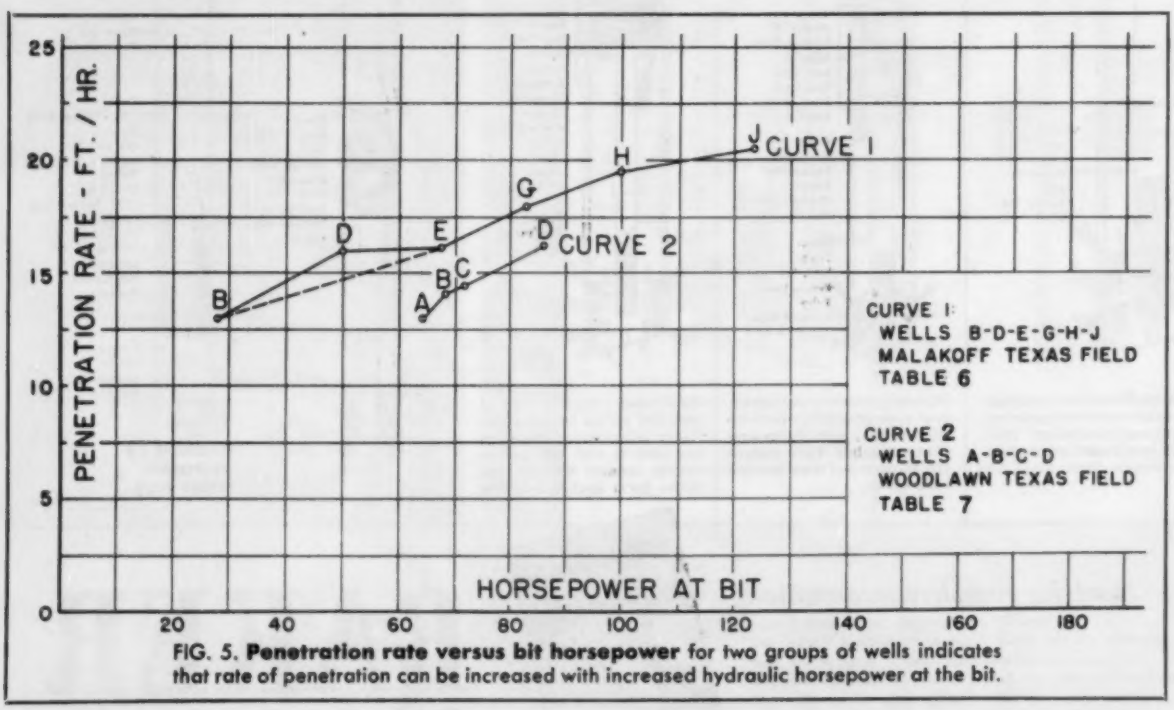

FIG. 5. **Penetration rate versus bit horsepower** for two groups of wells indicates that rate of penetration can be increased with increased hydraulic horsepower at the bit.

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On the other hand, only PGAC uses a special temperature-stable powder—and this powder is used in all PGAC bullet perforators. By contrast, when PGAC's special powder is identically exposed to 200°F. for 30 minutes or longer, its penetrating power is **actually increased** approximately 10%.

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MEMO: **For more data, please write PGAC's Houston office and request your free copy of "Gun Perforating Techniques And Applications," a reprint from a recent issue of The Drilling Contractor Magazine.**

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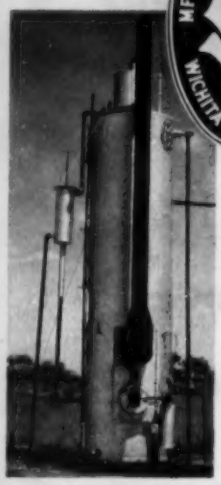

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2. It is believed a range of 100 to 150 ft per min is a safe annular-return velocity to use in the Ark-La-Tex area for corresponding penetration rates of 3 to 50 ft per hour, respectively.

3. A review of results using different nozzle velocities indicates the accepted minimum of 190 to 200 ft per sec to be applicable to the Ark-La-Tex area. We also agree that velocities of 220 to 250 ft per sec give better results when practical to obtain. There has been no optimum upper limit established, however. A review of the results indicates 250 ft per sec may be approaching the upper limit.

4. Using jet bits and based on the foregoing conclusions, rigs can, by utilizing as little as 115 input pump horsepower for 4½-in. drill pipe in an 8¾-in. hole and 146 input horsepower for 3½-in. drill pipe in a 7⅞-in. hole, jet drill to a depth of 6500 ft.

5. From the data accumulated the results tend to indicate a direct relationship between hydraulic horsepower and the rate of penetration (Fig. 5, curves 1 and 2).

Acknowledgment

The author sincerely appreciates the help and cooperation on the part of members of this subcommittee who assisted in gathering the field data referred to. ★ ★ ★

Southwestern API Meet Draws 800 to Fort Worth

Upwards of 800 oil men from New Mexico, and from North, West Central, and West Texas were in Fort Worth March 21-23 for the Southwestern district meeting of the division of production of the American Petroleum Institute.

This is the first meeting of the Southwestern District since the 1955 split which made two districts out of the API's former Gulf-Southwest region.

Two nationally prominent educators made the principal address. They were Dr. Clarence E. Manion, Dean Emeritus of the Notre Dame School of Law and one of the country's foremost constitutional authorities, and Dr. Otto R. Nielsen, Dean of the School of Education at Texas Christian University. Dr. Manion's subject was "Communism Is Controlled Government," while Dr. Nielsen's was "A Supervisor Is Human."

A. W. Thompson, of A. W. Thompson, Inc., Houston, and API vice president for production, spoke on "The Challenge of Drilling Costs."

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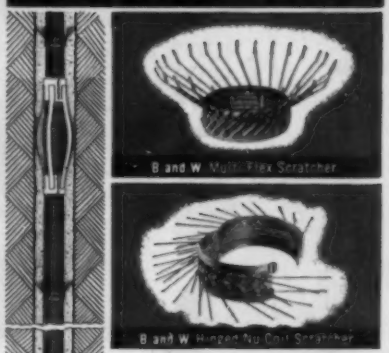
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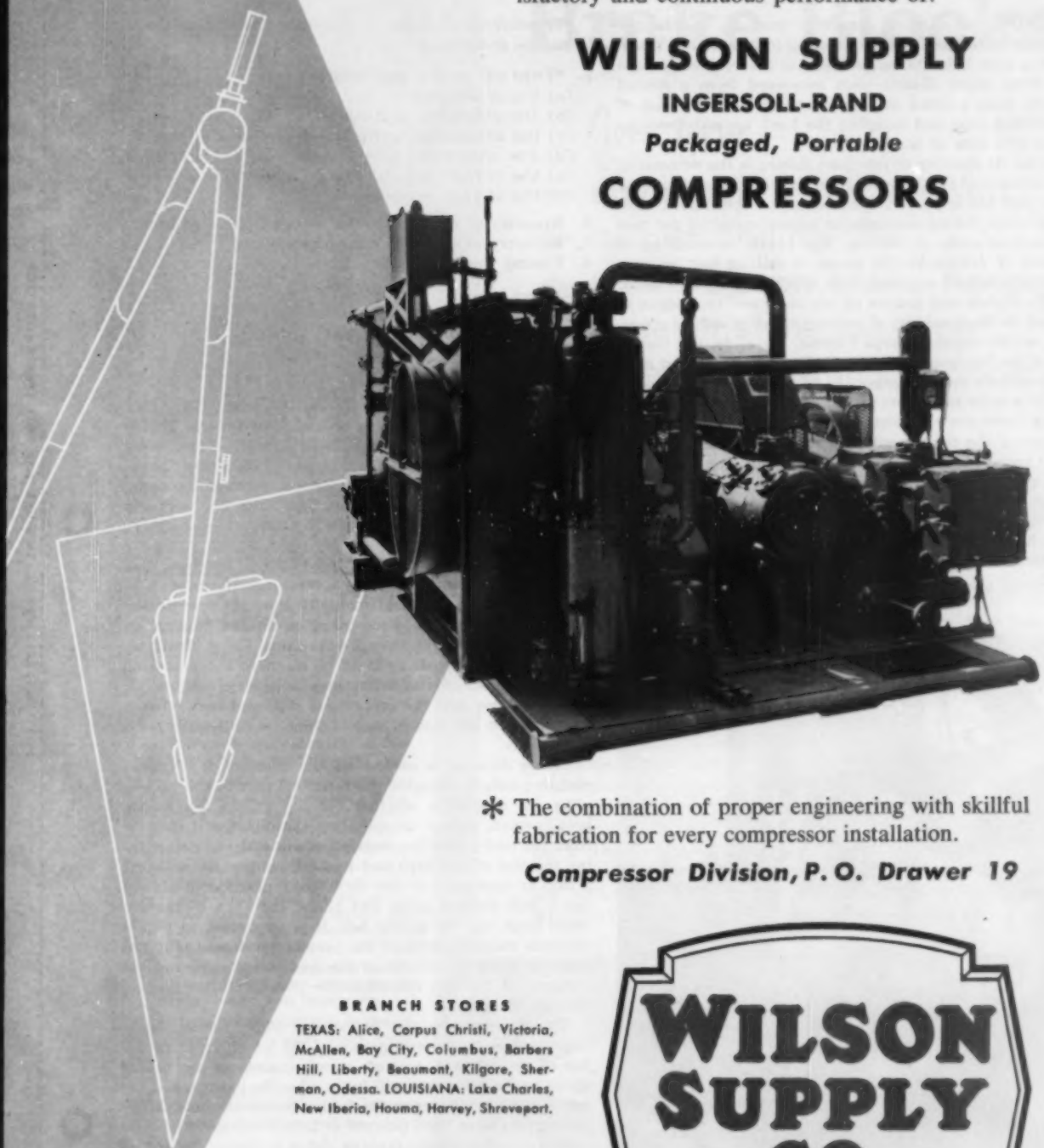

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FISHING AND FREEING STUCK DRILL PIPE

E. E. Moore*

FISHING is a word generally used to denote the operation of recovering or attempting to recover lost material in a bore hole. Its usage began in the very early days of drilling when objects were recovered from a drilled hole by tying a home made hook or spear on the end of the drilling rope and dangling the hook up and down by means of a pole or beam.

Unlike its sporting counterpart, fishing is the nemesis of the drilling, and to a lesser degree, the producing industries. Even with the improved equipment, and specialized tools and services, fishing accounts for approximately 3 per cent of the total costs of drilling. The yearly expenditure of millions of dollars in this phase of drilling has led to a highly specialized segment of an industry within an industry. To explain and discuss all the tools and techniques as applied to the hundreds of varying types of fishing operations, would require a large volume; therefore, this discussion of the fundamentals must be limited to the most common problems and the generally accepted methods of solution. It is to be remembered that today's accepted methods will be tomorrow's obsolete history.

Most of the tools mentioned are obtainable only on a rental basis, which includes the services of an expert, however, quite often a driller finds himself in remote areas or foreign operations with tools, but no expert advice. Even with the aid of an expert, it is important for the rig operator to have a working knowledge of the tools that will assist in coordinating the job to a faster conclusion.

*President, Moore Drilling Company, Ltd., Calgary, Canada.

Section of pipe recovered with a basket sub. Reed

For reference purposes an outline of the discussions to follow are given below:

1. **"Twist off" or drill pipe failure**
   - *(a) Use of overshot*
   - *(b) Use of overshot and mill*
   - *(c) Use of overshot and crooked joint of drill pipe*
   - *(d) Use of overshot with knuckle joint and drill hook*
   - *(e) Use of taper tap and Blondy Reynolds safety joint*
   - *(f) Use of under reamer*
2. **Recovery of rock bits, cones or small pieces of iron**
3. **Recovery of deviation survey instrument**
4. **Freeing stuck drill pipe**

Causes —

- *A. Stuck while on or near bottom*
- *B. Stuck lowering pipe in hole*
- *C. Stuck pulling pipe out of hole*

1. Remedy for "Twist Off"

The most frequent fishing job for the driller is for drill pipe as a result of drill pipe or tool joint failure. This is commonly called a "twist off," and usually occurs while drilling. The drill pipe loses its ability to stand the normal torque by excessive wear or by fatigue cracks in the metal caused from bending or tension. Pipe does not normally crystalize as commonly expressed, it either wears, corrodes or cracks.

An overshot is the most accepted tool for catching drill pipe or a tool joint. There are several manufacturers supplying overshots but fundamentally they all operate the same. Some use slips, some grapples for the "wedge" in the bowl, but basically they are the same. Fig. 1 illustrates both types. An overshot should be standard equipment on all rigs and should be maintained in good condition for immediate use with the proper size slips and pack-off rubbers to catch any size pipe, tool joint, or drill collar used in the hole.

Before dressing or assembling the overshot, it is important to carefully examine the retrieved part of the broken pipe and determine whether the top of the fish in the hole is worn, burred, or split, and the distance it may be from the tool joint. This inspection will assist in determining the size of the slips and pack-off rubber and whether a mill is necessary or not. It is good practice to always use a mill control guide just below the slips to remove burrs from the top of the fish. It is important to obtain accurate measurements of the overshot and especially the distance from the bottom of the skirt to the slips and the distance of the fish can enter the overshot after passing through the slips.

This information will be helpful while fishing. More important is the determination of the exact depth of the top of the fish and accurate measurements of the fishing string so the fisherman will know when he has reached the exact spot when lowering the fishing tool in the hole. Many fishing jobs have been delayed or failed because the fisherman was unknowingly probing above or below the top of the fish. If the top of the fish cannot be found and there is doubt as to its location, then an Electro-Log should be run to find the top.

After the overshot has been lowered to near the top of

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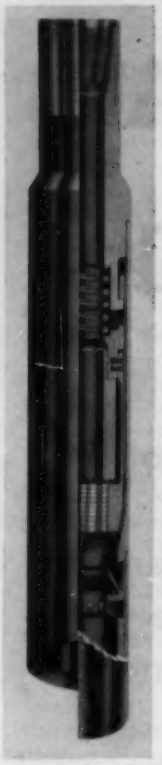
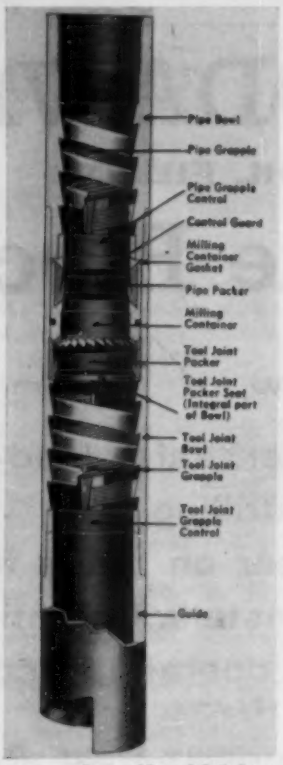


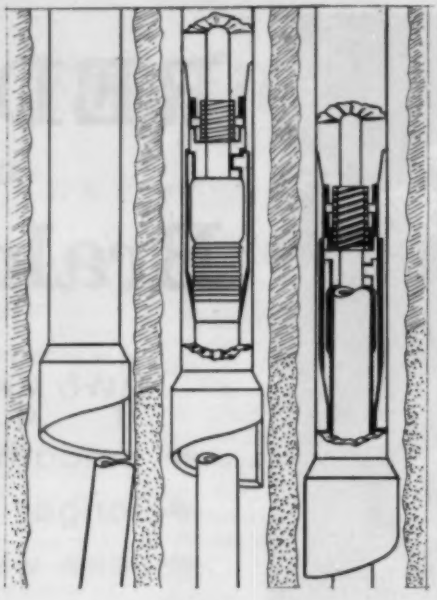
Brown Tool

Slip type releasing overshot.



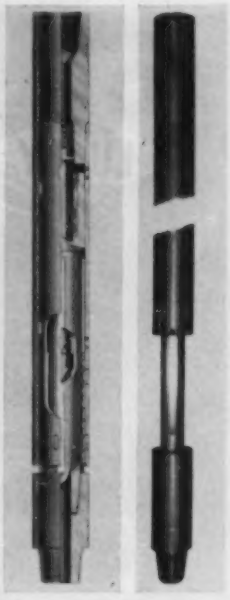
Bowen of Texas & S. R. Bowen

Two-bowl overshot fitted with spiral type grapples.



Overshot operation.

FIG. 1. Slip type and grapple type overshot. Advantage of double bowl is immediate readiness catch either pipe or tool joint.



Boash-Ross Wilson

FIG. 2. Two types of bumper subs. They are used to apply bumping action to loosen string.

the fish, mud circulation should be obtained long enough to clean the tool. It is not good practice to circulate more than a few minutes. It is good practice to have the mud and the hole above the fish in good condition before lowering the tool to the fish. Undue difficulties may arise if the fishing string is likely to stick at any time during the fishing operation. Ordinarily the mud is not circulated while actually fishing with an overshot. The chances are better that the pack-off rubber will hold after the fish is caught if the pump is not running while the fish enters the tool.

The actual catching of the fish may simply be to lower the overshot over the fish to the point where the top of the fish has passed through the slips and supports part of the fishing string. The fishing string is then raised, the slips or grapples wedge between the fish and the bowl thus catching a firm hold on the fish. Circulation should then be started through the overshot and on through the entire fish to properly condition the hole before pulling out.

The catch may not be simple and may require hours of patience and carefully raising and lowering, turning and feeling. This is where accurate measurements count in determining whether the overshot is passing by the fish, whether the bottom of the overshot is hitting the top of the fish, whether the fish will not enter the slips or whether the slips are not holding. During this operation, patience, imagination and carefulness are the watch words. Irrepairable damage may be done to the top of the fish by undue roughness. After the fish is caught and freed, the rotary table should be locked and the fish pulled without rotation to prevent dropping.

If the fish is stuck, all standard overshots will release their grip by having the weight of the fishing string applied and a turn to the right. When fishing at less than 2000 ft, it is good practice to run a bumper sub above the overshot. This allows a blow as well as weight to be applied in releasing the slips. A bumper sub is shown in Fig. 2.

(b) Use of Overshot and Mill

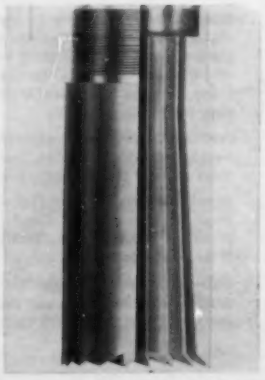
An overshot mill, shown in Fig. 3, is a cutting tool designed to run on the bottom of the overshot to dress the top of the fish to the proper diameter to allow passage into the overshot slips. Its cutting action is obtained by lowering the tool over the top of the fish and then slowly rotating. Its inside diameter and cutting edges are tapered and will progressively file the outside diameter of the fish to the dimension of the overshot slips.

(c) Use of Overshot and Crooked Joint of Drill Pipe

Quite often it is impossible to find the top of a drill pipe fish with an overshot. This is caused by an oversize hole allowing the fish to fall to one side as the overshot passes by. The first and cheapest operation is to put a double bend in the first joint of drill pipe above the overshot as illustrated in Fig. 4. The bent joint will force the lip of the overshot to the outside diameter of the hole. By raising and lowering the overshot with a few degrees turn

American I & M

Milling shoe.



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Milling guide.

FIG. 3. Mill is used on bottom of overshoot.

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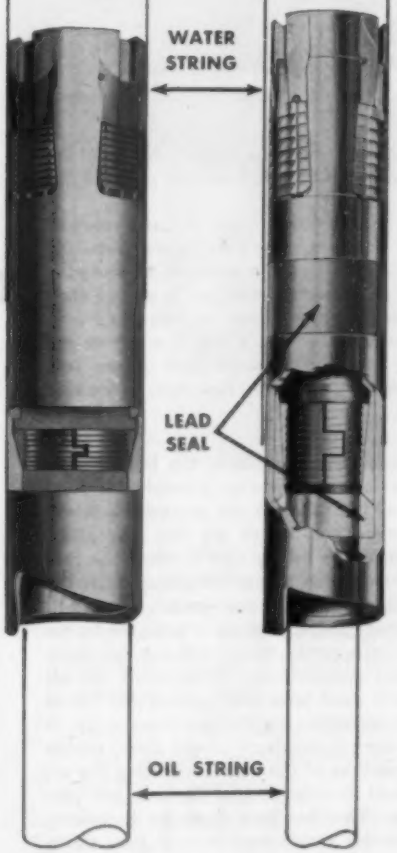

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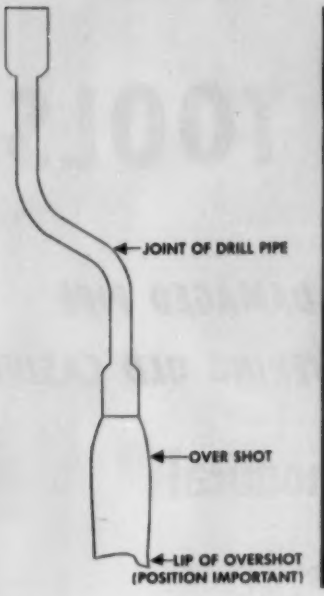

FIG. 4.

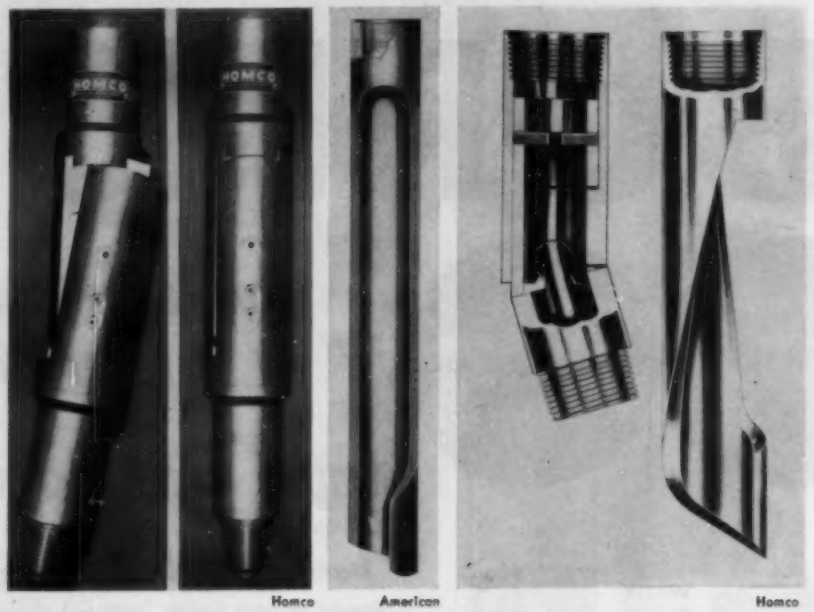

FIG. 5. Knuckle joints and wall hook for fishing in cavity. Overshot is placed between knuckle joint and wall hook.

each time the chances of finding the top and either going over it or changing its position to a more favorable one are good. The point of the overshot will naturally plow against the wall of the hole while running in and will require more care in so doing.

(d) Use of Overshot with Knuckle Joint and Wall Hook

The knuckle joint and wall hook are a combination of tools, Fig. 5, used to pull a drill pipe fish out of a cavity or large diameter hole and place it in a position to be caught by an overshot run just below the knuckle joint. This is ordinarily the tool chosen after the bent joint of pipe has failed. The knuckle or bending action is obtained by hydraulic pressure of the circulation mud. As the fishing string is slowly rotated with the mud circulating the wall hook is forced to the outside diameter of the hole or cavity and will hook the pipe.

After the pipe is hooked, one more round of torque is applied to the fishing string, the rotary table locked, the pump stopped and then the overshot lifted until the torque is released, then lowered. The weight of the wall hook and the torque should pull the fish to the middle of the hole directly below the overshot, which can be lowered over the fish. Here again measurements are important as it may be necessary to lower the overshot 20 to 30 ft below the top of the fish, in order to hook it with the wall hook. This necessitates lifting the fishing string with torque being applied to the exact spot where the overshot may then be lowered over the fish. This operation requires experience and may require hours or even days to successfully complete. A set of rotary jars is often run above an overshot to help free a stuck fish and it is to be remembered that a knuckle joint will withstand jarring upward, but not downwards.

(e) Use of Taper Tap and Blondy Reynolds Safety Joint

Quite frequently the joint of pipe being fished for in a cavity will be bent from compression of the drilling string weight, making it impossible for the fish to enter the overshot above the knuckle joint—wall hook combination. In that case a good tool is a "side kicking" taper tap with a Blondy Reynolds safety joint on the top of the first joint of drill pipe above the tap. The circulating hole at the bottom of the tap is plugged. A hole is cut in the side of the tap so the circulating mud pressure will force the point of the tap to the side of the hole.

The tap may then be lowered into the fish and screwed into it. After the tap has a secure hold on the fish, the Blondy Reynolds safety joint can be released by shearing pin and unscrewed by right hand rotation. It should then be possible to go over the good joint and the tap with washover pipe and outside cutters. A cut is made at the bottom of the cavity, the troublesome part of the fish, pulled out and then the normal overshot procedure resumed.

(f) Use of Under Reamer

If the above procedures are a failure, the hole can be under reamed to the largest diameter possible, at least 60 ft above the top of the fish and the procedures listed tried again. The oversize hole above the fish may allow sufficient space to enable the fishing tool to catch the fish.

If all these procedures have failed, whipstocking is the only answer. It is anticipated that a chemical cutter will be available in the near future, making it possible to cut the pipe at the bottom of a cavity, which will convert many failures into successful completions. Occasionally an oil and high pressure water sand have been penetrated below the top of a fish that cannot be caught due to a cavity. It may be desirable or even compulsory to get down beside the drill pipe to the section of the hole separating the oil sand and the water sand in order to seal the hole and prevent reservoir damage. This has been done by cementing the top of the fish in the cavity and then drilling along side the fish. Attempts to drill alongside without cementing have failed.

2. Recovery of Rock Bits, Cones or Small Pieces of Iron

Small pieces of iron can be recovered by running a magnet on the bottom of the drill pipe. Circulation should be obtained to clean the cavings in the bottom of the hole to allow direct contact between the magnet and the iron. A basket may be used. This is simply a 2 to 3-ft core barrel. A short core is cut thereby trapping the iron in the barrel. There are many shapes of side door baskets and junk subs designed with a pocket to catch small pieces of iron as

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These shops have a full stock of Cabot parts and Cabot's own service men. They are open 24 hours per day.

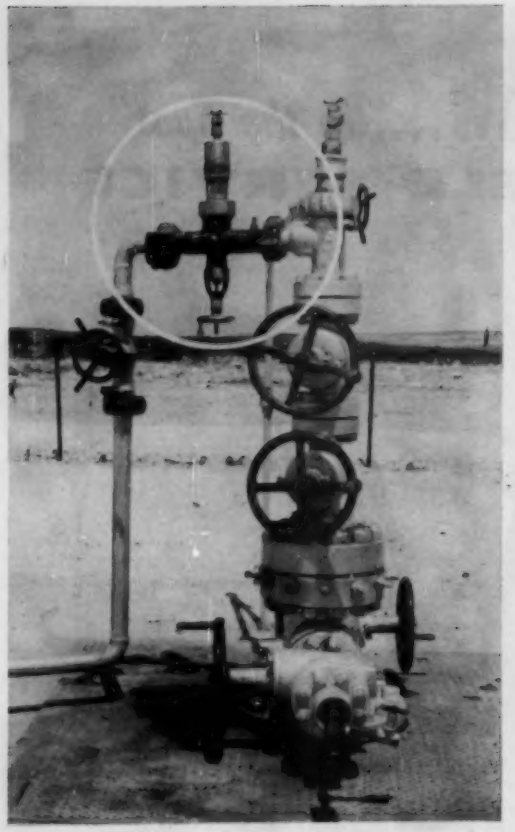
Interchangeable reducers, structures, bearings and accessories permit a wide variety of combinations . . . of exceptionally sturdy design with large walking beams, heavy four-legged samson posts, and deep, wide-flanged steel base members . . . equipped with floor clearing sub-bases, eliminating the construction of an expensive foundation in the field.

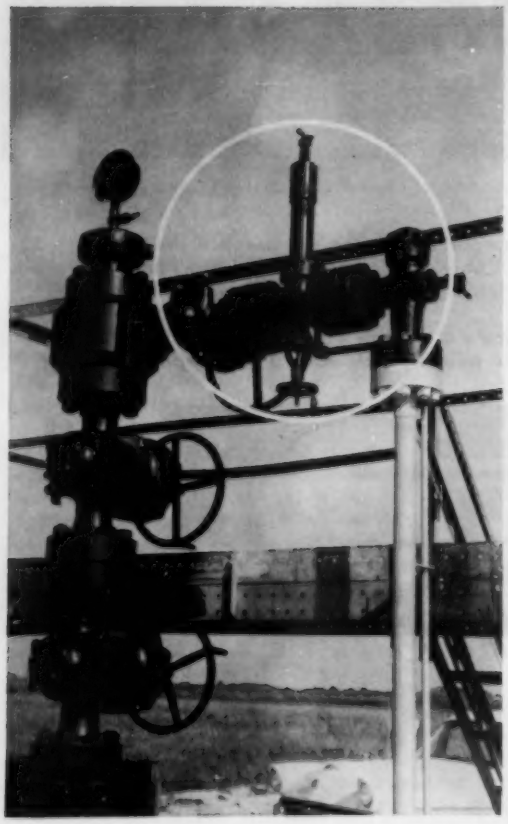
In comparing pumping unit prices, it should be noted that Cabot's basic prices include many items that are available only at extra cost on most other units.

There's a quality Cabot pumping unit to meet your needs. *Call your J & L Supply Man.*

DIVISION OF CABOT SHOPS, INC. FRANKS

CABOT SHOPS, INC.
PAMPA, TEXAS
"ON THE SPOT" FIELD SERVICE





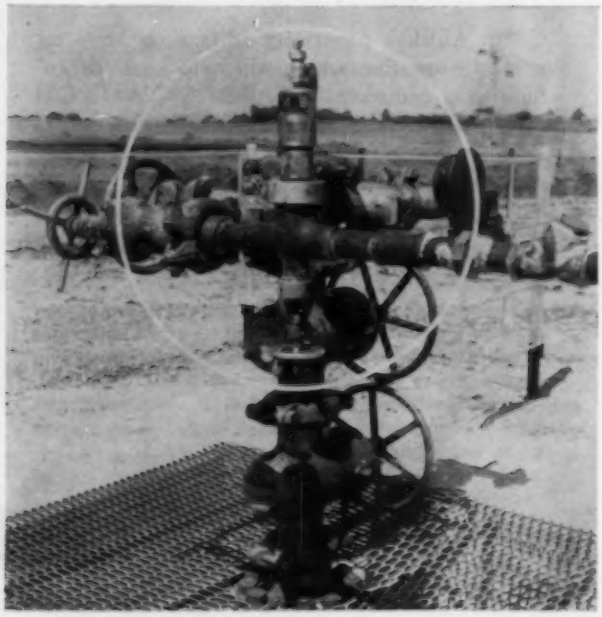
EMERGENCY

NO OTHER INVESTMENT MEANS SO MUCH OR

Safety minded companies do not risk the lives of their personnel when safety and protection costs so little.

An **A-1 Safomatic Valve** installed on the Christmas Trees and flow lines of your wells is the equivalent of a "safety minute man" — any time pressure in the line, due to line breakage, freezing, etc., rises or falls below pre-set safety limits the flow is shut-off instantly by the **Safomatic.**

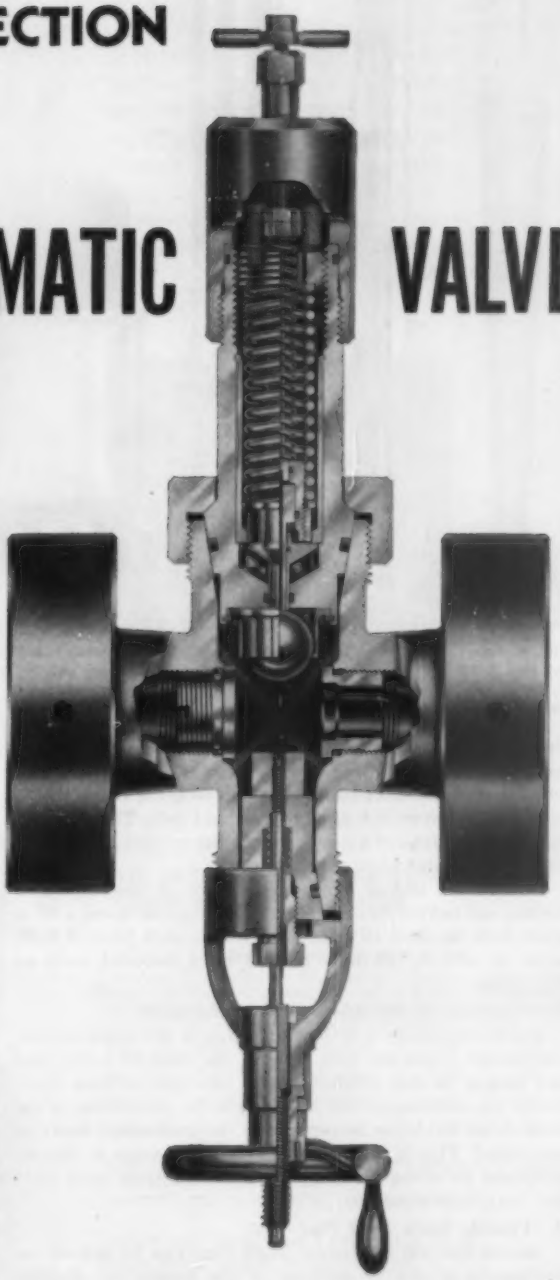
Damage to equipment such as heaters, treaters, separators, dehydrater units and other equipment due to line breaks or drastic pressure increases is prevented by the **A-1 Safomatic.** The loss of oil or gas from remotely located wells is eliminated, whether the lease operator makes occasional or closely spaced visits. The damage in residential and industrial areas is also eliminated by the "safety minute man" efficiency of the **A-1 Safomatic.** The records achieved in actual field service is proof to today's safety minded operators that the **A-1 Safomatic Valve** — costing less than 1/100th of the surface equipment for most high pressure oil or gas wells, is the best protection money can buy.



SHUT-OFF

IN SAFETY AND PROTECTION COSTS SO LITTLE

A-1 SAFOMATIC VALVE



How the **Safomatic** has paid off in Safety and Protection . . . Better than Insurance.

A-1 SAFOMATIC CREDITED WITH SAVING LIVES OF TWO MEN. This incident occurred at a gas injection project, operated by a major company below Morgan City, La. Due to an error in operation at the compressor station, the wrong valve was closed causing a rapid pressure build-up that threatened to blow-up the low pressure lines. The **Safomatic** shut-in instantly protected the system against the high pressure which could have caused a blow-out. A-1 personnel were told that the action of the **Safomatic** valves was responsible for saving the lives of two fieldmen and preventing extensive damage.

SAFOMATIC PREVENTS ESCAPE OF HYDROGEN SULFIDE. In West Texas, a major producer had a 4" **Safomatic** on a line carrying sour gas at 1035 psi. A two foot split in the buried line blew a hole in the ground large enough to hide a car. The drop in line pressure instantly closed the **Safomatic**, shutting in the line and preventing the loss of gas, which would have created a dangerous hazard, by its escape.

SAFOMATIC SHUTS-IN WELL WHEN FLANGE BURSTS. A Tool Pusher searching for a supply of gas for drilling operations, heard a flange burst as he approached a high pressure gas well. Starting to run to safety, he noticed the flow had stopped. Stopping to investigate, he saw that the **A-1 Safomatic** had shut the well in, and all was safe. He then notified the well owner.

TUG BREAKS FLOW LINE — SAFOMATIC SHUTS-IN WELL. South of Lake Charles, La., a pumper making his routine check discovered a well shut-in. Going out to the platform in the bay he found the **Safomatic** had shut it in. When he opened the safety valve, gas bubbling in the bay indicated a line break. The **Safomatic's** emergency shut-off prevented loss of gas that would have occurred from the time the line was broken by a passing tugboat, and its discovery by the pumper.

WELD FAILURE CHECKED BY SAFOMATIC. When the weld on a water knockout on a well below Abbeville, La., failed at operating pressure of approximately 4500 lbs., the **A-1 Safomatic** instantly shut-in, preventing loss of gas and damage to the well, equipment, and property.

SAFOMATIC SHUTS-IN WELL AFTER CHOKE FAILURE. A major company's oil well near Beaumont recently had a choke failure. In a matter of a few hours, the choke cut-out completely. The flow chart showed a gradual increase in pressure until it reached the preset pressure limit of the **Safomatic** which instantly closed and shut-in the well. No damage to line or flow equipment was experienced.

A-1 BIT AND TOOL COMPANY

P. O. Box 2133 **Houston, Texas** **JA 9-3831**

DISTRICT OFFICES AND SERVICE POINTS: TEXAS: Beaumont, Corpus Christi, Linden, Midland, Victoria. LOUISIANA: Lafayette. OKLAHOMA: Oklahoma City. WYOMING: Casper (James Emrick Co.). NORTH DAKOTA: Tioga.

FIG. 6. Taper taps, junk baskets and magnetic fishing tools. Taper tap and releasing spear are used to catch inside pipe. Junk catcher picks up any fish or junk left in hole mechanicall. Magnetic tools use a permanent magnet.

they are pumped off bottom. They are used just above a hard formation rock bit. The secret is to break them into small pieces and alternately start and stop the pump which alternately forces the junk to rise and fall. This method has the advantage of allowing the driller to drill ahead once the iron is trapped and save trip time.

A rock bit, slip or similar size piece of steel must be broken up before fishing it out. This can be done with a down hole jet shot, 10 qt of nitro, with a slick joint of N-80 pipe, or with a full hole mill of hard material, such as Klustrite.

3. Recovery of Deviation Survey Instrument

Quite frequently a driller will drop a deviation survey instrument down the drill pipe at the start of a trip and not realize he has twisted one or two drill collars. Invariably the instrument will fall outside the drill collar in the hole. After the collar is recovered, the instrument must be recovered. This is easily done without damage to the instrument by using an overshot with a bottom skirt near the bore hole diameter.

4. Freeing Stuck Drill Pipe

Before the job of freeing stuck pipe can be started intelligently, a careful analysis of the reason for sticking must be made, as the approach depends upon the reason. Basically, it is usual to try to move stuck pipe in the opposite direction it was travelling when it became stuck. The most common reasons for stuck pipe are:

Causes and Remedies

While on or Near Bottom

1. Formation sloughing, caving or bottom cutting accumulating around the pipe faster than the circulating mud can lift it from the annulus.

When pipe is stuck on or near bottom while drilling, making a connection, or starting to hoist the pipe, it is usually caused by cavings and cuttings accumulating around the bit and drill collars. An analysis of the amount and type of cuttings going over the shale shaker is a good clue of how much and where the hole is caving. It is then good procedure to continue mud circulation and improve the mud characteristics to not only assist in carrying the cavings to the surface, but to prevent further caving. The pipe should be pulled up and lowered every few minutes to prevent sticking higher in the hole. Too vigorous or frequent working of the pipe will whip the walls of the hole and may induce further caving.

If after the mud is conditioned properly and the cuttings on the shaker indicate the mud and hole is clean, consideration should be given to "spotting" oil, water or acid. This is accomplished by pumping the chosen fluid down the drill pipe and around the bit and drill collars. In the case of oil, the drill pipe is usually left full and moved downward every 30 min by a few strokes of the mud pump. On deep holes, it is wise to have a Kelly Cock under the swivel that may be closed if the high back pressure causes a leak in the surface mud line or hose and creates a fire hazard. Acid and water give quick results if successful. Oil may require 8 to 48 hours. The past experience of the local area will dictate whether any of the fluids are worthwhile.

The next step, after hydraulics have failed, is to run a free point indication or Magna-Tector inside the pipe to

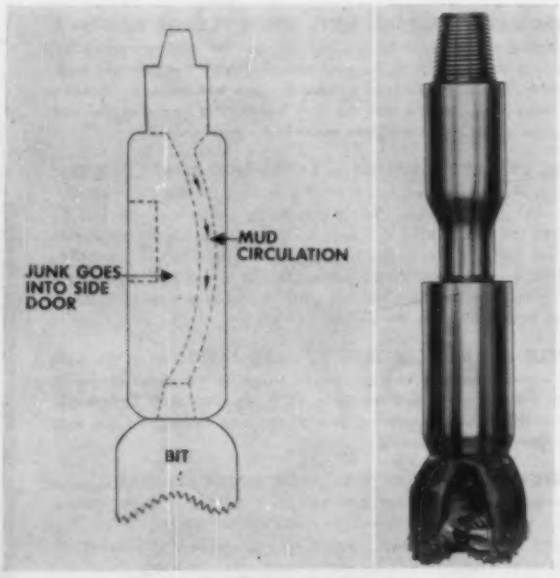
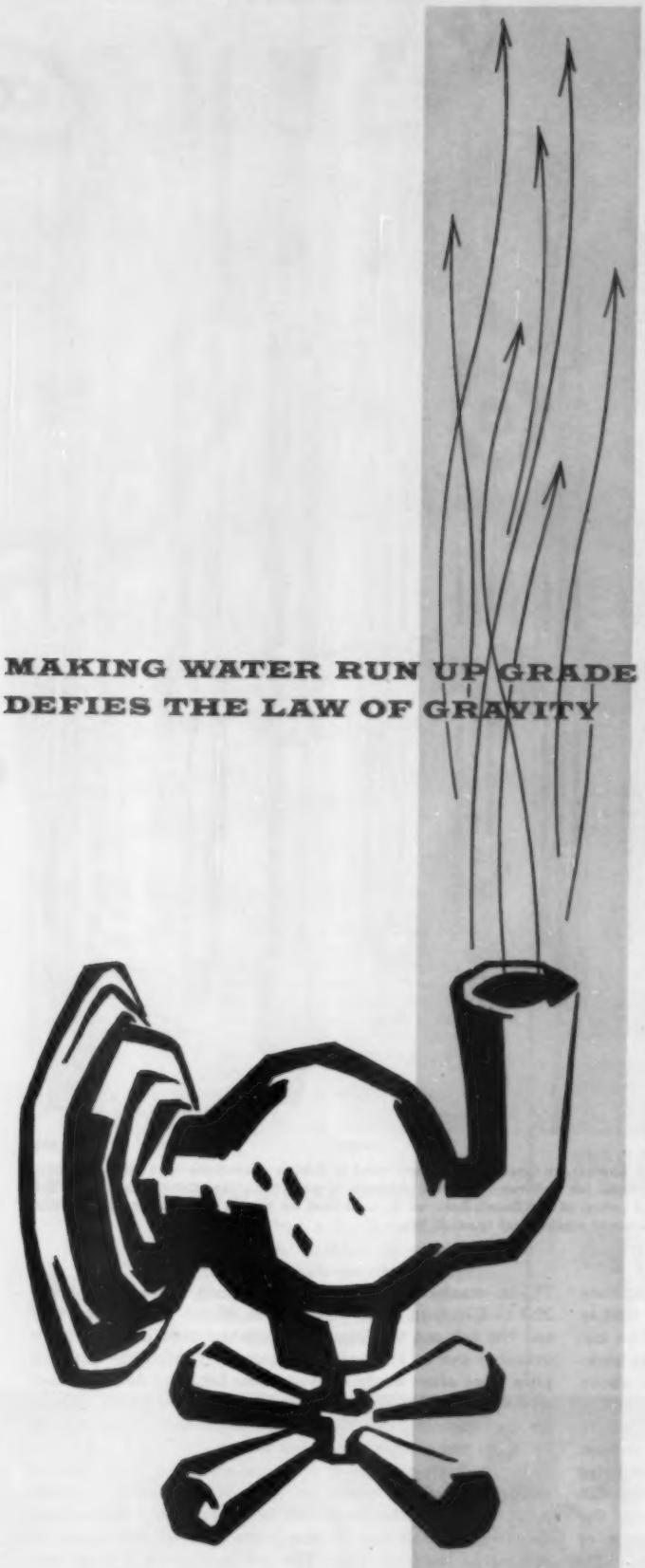


FIG. 7. Basket sub and how it works.

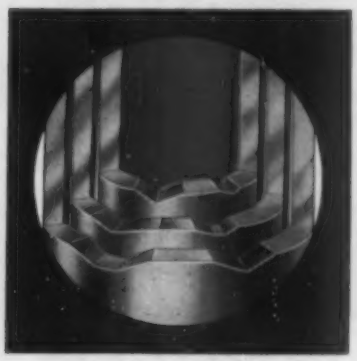
CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE

MAKING WATER RUN UP GRADE DEFIES THE LAW OF GRAVITY



Lifting water in the oil fields presents a like problem — whether it be a water supply well for a flood or just a plain wet oil well.

Fluid Packed Pump Co., in recognition of the Oil Industry's need for a Down Well Rod-Drawn Pump that will economically and efficiently handle large volumes of water, has applied the Multiple Tube Principle to its design of an over-size pump. The Multiple Tube Pump, by reason of its sleeve type construction, will maintain its maximum rate of efficiency in water, and does not require lubrication for successful operation.



The fluid packing between the tubes eliminates the need for lubrication.

The **OVERSIZE OILMASTER MULTIPLE TUBE PUMP** can be installed or removed on the rod string. The pump can be seated in a shoe on the bottom of large tubing or on a Packer Type, vertically setting Pump Anchor designed to set in the casing string.

SPECIFICATIONS

Pump Bore	Pump O.D.	Tubing or Casing Size	Bore Factor*	Maximum Stroke
2¼"	2¾"	3" or larger	0.590	166"
2¾"	3⅛"	4" or larger	0.881	166"
3¼"	3⅝"	4" or larger	1.232	166"
3¾"	4"	5½" or larger	1.640	166"

*BORE FACTOR X STROKE LENGTH IN INCHES X STROKES PER MINUTE EQUALS BARRELS PER 24 HOURS.
EXAMPLE: 1.640 X 74" STROKE X 15 SPM—1,820 BARRELS.

Contact your nearest Fluid Packed Pump Co. representative or write for further details.

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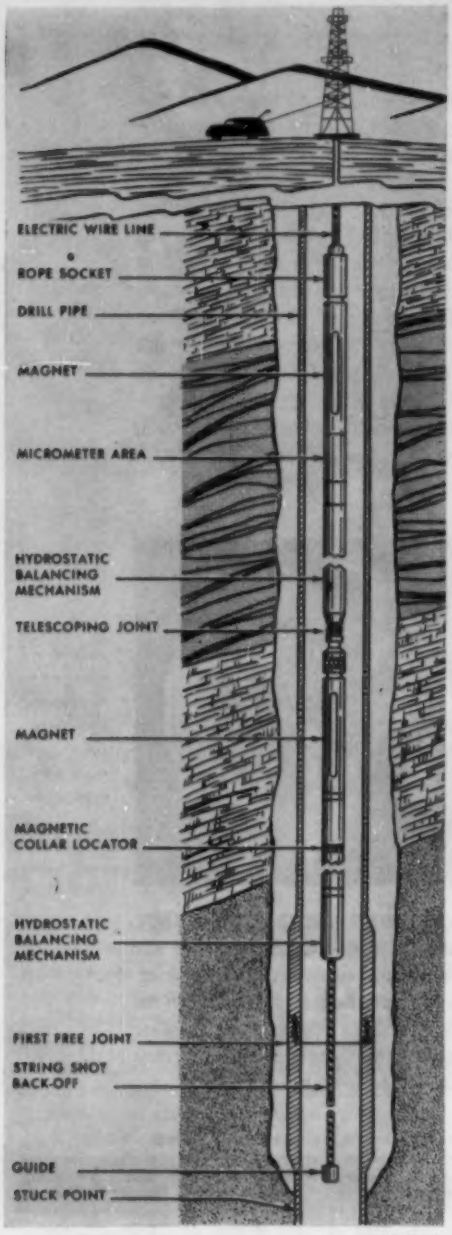


FIG. 8. Magnetic detector and string shot backoff.

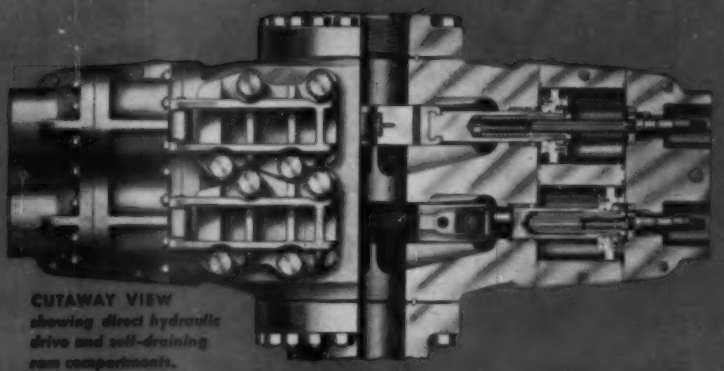
FIG. 9. Shown are three types of jars used in fishing operations—the Homco impact or nitrogen jar delivers its action through a gas-driven free-moving hammer. The jarring action of the Baash-Ross jar is controlled by torque or drillstem. Bowen tool is a straight mechanical type oil jar.

determine the stuck point. These instruments indicate where the pipe fails to develop torque or tension that is applied from the rig floor. The free pipe can then be unscrewed by torqueing to the left, and with an explosive back-off shot properly placed in the tool joint, one joint above the stuck point.

The surest procedure to recover the stuck pipe left in the hole is to run a string of wash-over pipe on the bottom of the fishing string. The size of hole, the outside diameter of the pipe, and collars in the hole, the length of the fish and the general condition of the hole will determine the size and length of the wash-over pipe and the type of drilling shoe on the bottom. For instance, 6-in. tool joints and 6¼-in. drill collars in a 9-in. hole would accommodate 7⅝-in. wash-over pipe with an 8½-in. shoe. Ordinarily, 200 to 500 ft of wash-pipe is safe. If the bit is on bottom and the fish not too long to be washed over in one try, an overshot can be run properly spaced to catch the top drill pipe joint after washing over to he bit. The fish is pulled with the wash pipe. If only drill collars are in the hole, a back-off tool can be properly spaced to screw into the top collar as the washover reaches the bit.

If the back-off tool is not available, the wash pipe is pulled and a trip made with an overshot or a screw-in joint to recover the freed fish. If the fish is on bottom and too long to wash over in one try, a back-off tool is run at the top of the wash pipe. The full wash over is made and the back-off tool screwed into the top of the fish. A free

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE.



CUTAWAY VIEW
showing direct hydraulic drive and self-draining ram compartments.

✻ When selecting cellar control gates, remember this...one gate may offer one feature — another gate, a different feature. But NO gate offers *so many* outstanding features as do Shaffer Hydraulic Cellar Control Gates!

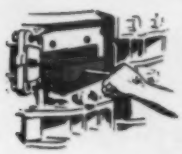
In Cellar Control Gates

You can't buy better than Shaffer!

FIRST SAFETY...

and on this extremely important point, every Shaffer product is backed by over three decades of experience and highest performance standards. But look for more than safety alone...

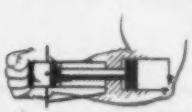
PLUS EASY RAM CHANGES!



As wells are drilled rams must be changed frequently to meet requirements of varying pipe sizes. In Shaffer Hydraulic Gates you simply open doors in the *side* of the gate, slide out the ram assembly, change rams, slide the assembly back in place and bolt the doors. It's that simple!

And equally easy ram changes can be made whether pipe is in or out of the hole.

PLUS POSITIVE, DIRECT DRIVE!

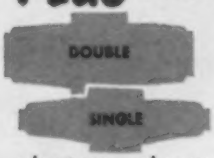


Shaffer Hydraulic Gates have no complicated hook-ups or secondary connections between rams and operating cylinders. Pistons are *directly behind* the rams for fool-proof operation, fewer parts, positive simplicity.

PLUS REAL COMPACTNESS!

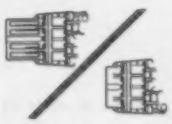
Shaffer Hydraulic Gates are not only amazingly compact in all three dimensions—length, width and height — but there's no need to expand critical end dimensions in order to change rams — nor need extra space be allowed above the gate to provide room for removing or inserting the rams. Even in sizes as large as 13⅝" (12" Series 900) Shaffer Hydraulic *Double* Gates require only 30" total height — *Single* Gates only 18½". Length and width dimensions are comparably compact!

PLUS SINGLE or DOUBLE DESIGN!



With Shaffer Hydraulic Gates you not only have a choice of Single Gates or Double Gates (two ram compartments unitized into one compact body), but both designs offer the same basic operating advantages, and many parts are interchangeable between the same sizes of Single and Double Gates.

PLUS RISING or NON-RISING SHAFTS!



Some operators prefer the "Rising" type of Locking Shaft because of its quick indication of ram position — others prefer the "Non-Rising" type for its greater compactness. Take your choice — Shaffer provides both to meet *your particular* preferences.

✻ Plus MANY OTHER ADVANTAGES: *Get the complete story from your nearest Shaffer representative — or write direct.*

See the Shaffer Section of your Composite Catalog.

Write for your free copy of the latest Shaffer Catalog!

SHAFFER

HIGH PRESSURE DRILLING AND CONTROL EQUIPMENT • FISHING TOOLS THAT EXCEL

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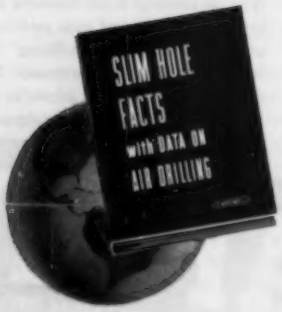
33 years OF OIL TOOL LEADERSHIP!

Cardwell's

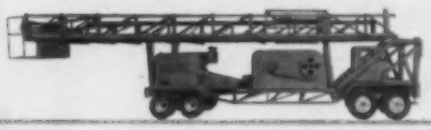


There's a world of information in Cardwell's book, *"Slim Hole Facts with Data on Air Drilling."* 225 pages, covering Economic Considerations, Representative Drilling Programs, Drilling Techniques, Completion Techniques, Equipment Considerations including rigs, pumps, drill pipe, drill bits, and transportation charges, and an entire section on Air Drilling. This book is free to contractors and oil company executives. Write Philip L. McLaughlin, Director of Drilling Research, Cardwell Manufacturing Co., Inc., on your company letterhead.

WORLD-WIDE EXPERIENCE

LEADS THE WAY TO

REDUCED DRILLING COSTS



30 years' experience . . . just the starting point for Cardwell's development of higher quality, more efficient rigs for Slim Hole drilling, "Big Hole" drilling, servicing, and workover operations.

Today . . . Cardwell's improved organization with wider resources and broader experience is directing its advanced planning toward your drilling and servicing problems in a determined effort to bring you new and improved rigs that will reduce your costs.

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point indicator is then run and the fish backed off with the aid of a string shot. The free fish is then recovered with wash pipe and the procedure duplicated until the entire fish is recovered. If the stuck string is off bottom and it is undesirable to drop it to bottom when it is washed free, an overshot to catch a drill pipe tool joint is run one joint from the bottom of the wash pipe. This overshot will prevent a tool joint from falling through it. There must be one free joint of pipe at the top of the fish to allow the overshot to go over the tool joint before washing over is started, hence the necessity for leaving one free joint when backing off.

It is standard practice to run a set of rotary jars (Fig. 11) and a safety joint with wash-over pipe to assist in freeing or to get loose from the wash-over pipe in case it becomes stuck.

2. Pipe not in motion allowing the sticky formation or wall cake to set like glue against the pipe, or if mud circulation is stopped alllowing the cuttings to settle around the pipe or drill collars.

In areas that are known to stick pipe quickly that is not in motion, it is good practice to get loose at the free point as quickly as possible and start the normal wash-out procedures.

3. Lost circulation causing the hole to cave or be "sucked" around the pipe.

Some knowledge of an area and a formation is helpful in freeing stuck pipe due to lost circulation. Pipe stuck in surface gravels and sands due to lost circulation can usually be freed by sealing the thief formation with lost circulation material until it will stand sufficient pressure to clean the hole. When it is known that circulation will be difficult to establish, the free pipe should be backed off and circulation established before washing over procedures started.

B. Lowering pipe in the hole forcing the bit into cavings or an under gage hole drilled b ythe previous worn bit.

Pipe stuck while running in the hole can usually be freed by backing off at the free point and screwing in with a set of rotary jars and driving upward. If this is unsuccessful, a wash-over procedure is in order.

C. Pulling pipe out of hole.

1. An accumulation of cuttings and cavings collect on top of bit and around the drill collars until sufficient to stick.

2. Pulling drill collars into a key seat.

Pipe stuck above 2000 ft while pulling out of the hole can often be jarred loose by driving down with a surface driver, shown in Fig. 9. If 2 or 3 hours of driving does not free it, then it should be backed off with a free point indicator and back-off shot and a set of rotary jars used to drive downward first and upward last. An overshot should be used below the jars to insure getting loose from the fish without using the free point tools again. Enough drill collars should be run on top of the jars to give enough weight for the desired blow downward. Pipe that has been pulled considerable distance into a tight spot and stuck is very infrequently freed by jarring either from the surface or below. The capacity of the derrick and the damage to the hosting equipment should be considered a in a jarring operation.

K & G

FIG. 12. Drill pipe junk shot used to break up bits on bottom of hole.

Christensen

FIG. 14. Diamond wash-over shoe used as a burning joint or bit in reducing OD of tool joints, collars, and equipment stuck in hole.

FIG. 13. Inside cutters run on tubing or sucker rods to free pipe.

Shaffer

Pipe is frequently stuck by pulling into a key seat (Fig. 10). It has been proven conclusively many times that key seats can occur in holes with deviations of less than one degree. This is due to a change in the direction of the deviation usually 180 deg. Holes that have required 30 to 40 days to drill to 7000 to 8000 ft are likely prospects for key seats at 2000 to 3000 ft in many areas. A key seat will usually give warning to an alert driller by hanging slightly for two or three trips before sticking. A change in the number of drill collars may result in sticking in a keyseat the first trip out. Drill collars can usually be jarred downward and freed from a keyseat, but there remains the problem of pulling out which may be difficult or impossible. The safest procedure is to back off one or two joints above the stuck point with the aid of free point indicator and backoff shot. Then go in with washover pipe and hole size shoe. This reams out the key seat and eliminates it for two or three weeks of drilling and frees the stuck collars at the same time. An overshot properly spaced in the wash pipe will prevent dropping the collars when they are free.

It is realized that the proper tools are not always available and that the best tools and procedures often fail, but it is felt that adherence as closely as possible to the best accepted methods, as outlined, will result in a high percentage of succeses.

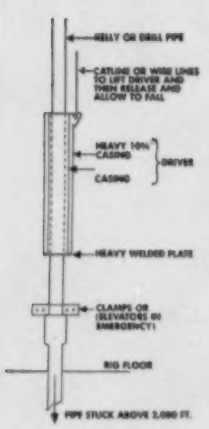
KELLY OR DRILL PIPE
CATLINE OR WIRE LINES TO LIFT DRIVER AND THEN RELEASE AND ALLOW TO FALL
HEAVY 10¾ CASING
CASING
DRIVER
HEAVY WELDED PLATE
CLAMPS OR ELEVATORS (IN EMERGENCY)
RIG FLOOR
PIPE STUCK ABOVE 2,000 FT.

FIG. 10.

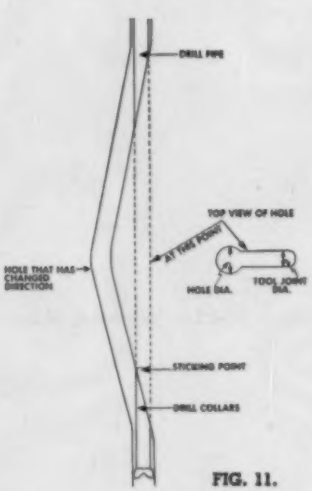

FIG. 11.

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE.

National's rig-up service

pays dividends at the well site!

Would you like to arrive at your next well site knowing you're *fully* prepared for the job? A growing number of National Supply customers are doing so these days—because of our rig-up service on new equipment.

Here's how this outstanding service works. At a National plant, store or your own equipment yard, we assemble—or direct the assembly of—the complete rig. If you furnish the crew, they become familiar with the rig before it goes to the field. After assembly, the rig is test-operated for as long as 48 hours, lubricated and adjusted. Any needs that may cause an initial delay in the field are promptly filled. If you desire guide photographs and paint-coded parts for re-assembly, these are also supplied. Then the rig is dismantled and shipped to the well site.

During this test rig-up, all necessary parts and services are immediately available. While you pay the expenses, you don't have to pay "road time" for rig-up trucks and welders. You can better anticipate *all* your operating needs, and save much valuable time. Customers taking deliveries of such test-assembled rigs report *better rig-up jobs at lower cost than previous field assemblies!*

National's optional rig-up service is especially useful for the larger Ideal Rigs you'll see on the next two pages. It's not a new service—particularly for our export customers in all parts of the free world. But it is, like using dependable "National Blue" oilfield equipment, one of the best kinds of drilling insurance you can buy. The National representative or store personnel in your area will be glad to tell you more about it.

THE
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COMPANY

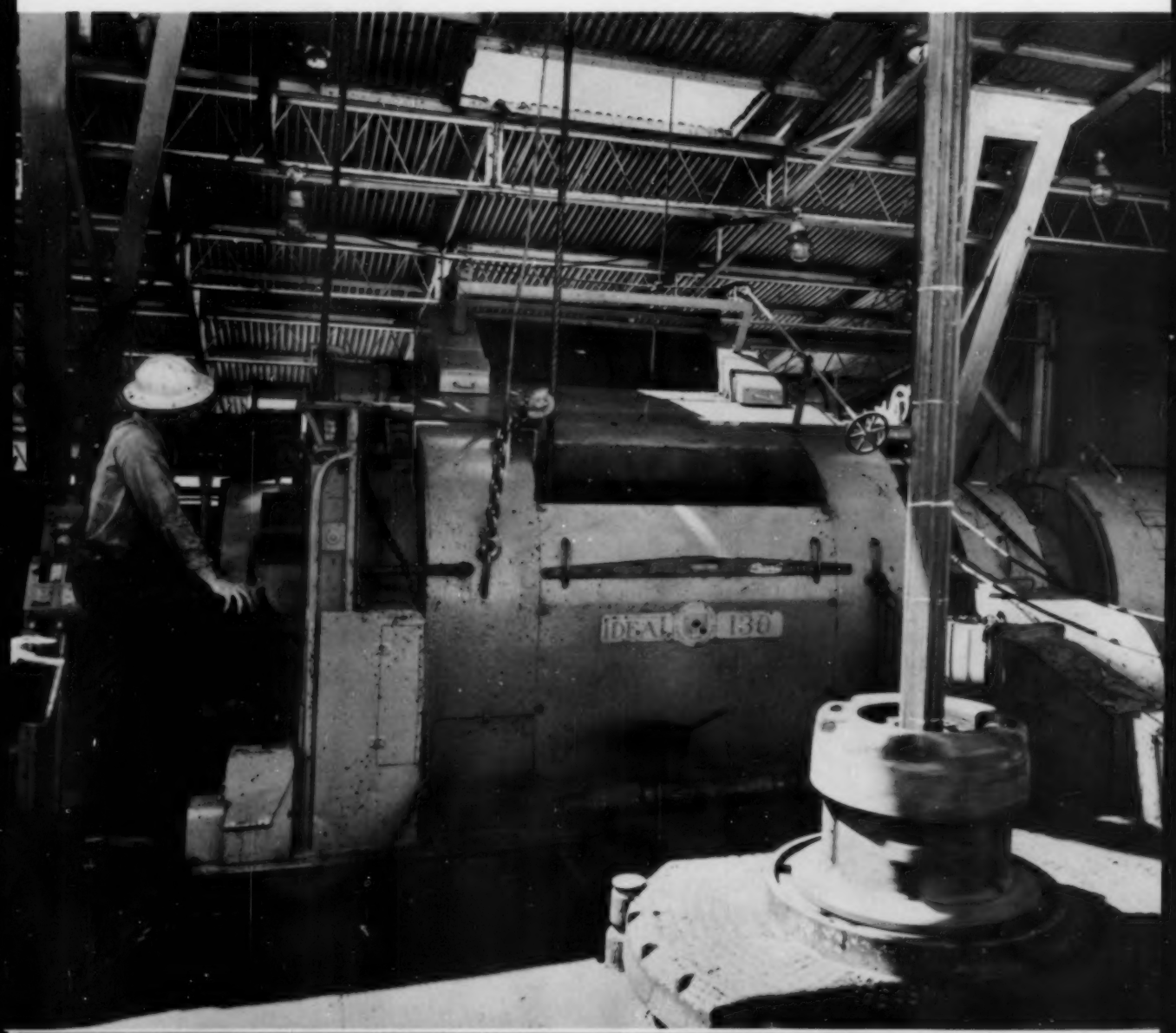
Smooth-running IDEAL® Rigs keep costs low.

You can operate the Ideal Rig for your needs in the desert, at sea or just a few miles from home—it will do the same dependable job for low-cost footage everywhere. That's because it's engineered for smooth, fast operation, and has all the modern features you require in a trouble-free rig.

Take the Ideal Type 110 on the next page as an example. Its compact construction, large drums and features for easy operation are typical of all Ideal Rigs. So, too, is the special sectionalized design that makes it easy and economical to move anywhere. It has National's own Dy-A-Flex clutch, exclusively designed for rugged oilfield service—and all working parts are easily accessible. In these and other construction details you get the convenience that means ease in handling, control and routine operations—including maintenance.

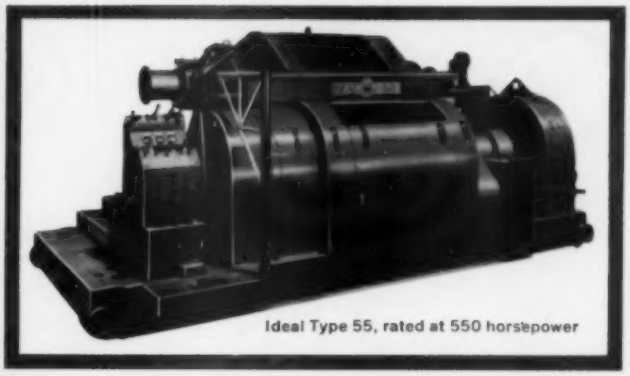
Every Ideal Rig is backed by National's continuous research and years of close cooperation with practical operators the world over. Remember, too, that wherever you operate an Ideal Rig, you're not far from the prompt service which is available through National's extensive field supply network.

Let the National Supply representative in your area tell you more about the Ideal Rig that can keep your drilling costs low!

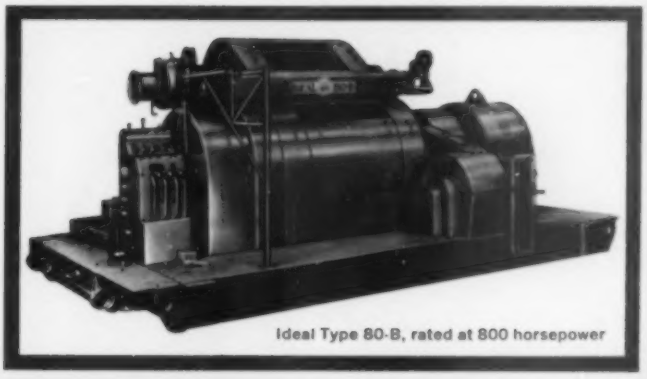


. wherever you operate!

Ideal Type 50-A, rated at 450 horsepower



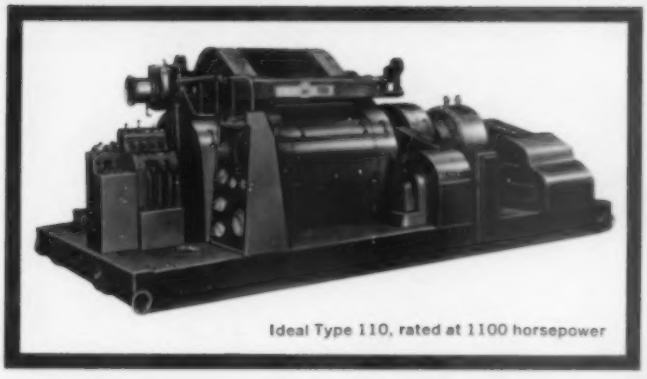
Ideal Type 55, rated at 550 horsepower



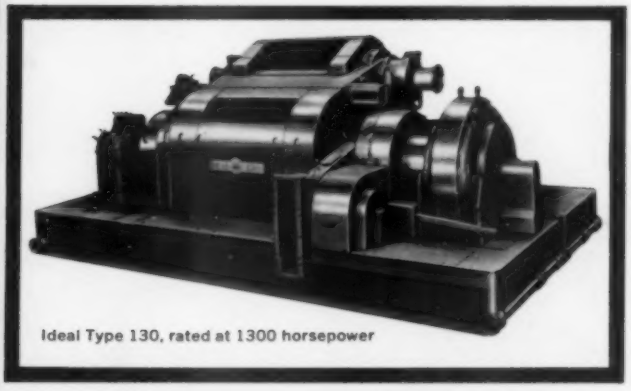
Ideal Type 80-B, rated at 800 horsepower

The big rigs for your big jobs

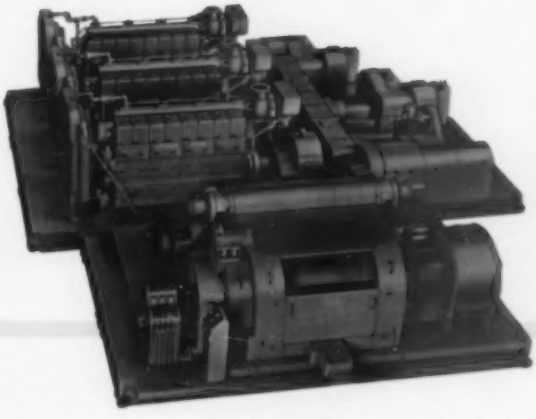
There's a smooth-running Ideal Rig for every drilling job—and these six cover the range of the "big" jobs from medium-depth to deepest drilling. Each has been developed for the most efficient operation at rated capacity, and is built for long, hard service. Four other rigs, designed to operate from trucks and trailer mounts, make up the balance of National's complete 10-rig line.



Ideal Type 110, rated at 1100 horsepower



Ideal Type 130, rated at 1300 horsepower



Ideal Type 160, rated at 2000 horsepower

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NATIONAL BLUE OIL FIELD MACHINERY AND EQUIPMENT
SPANG STEEL PIPE AND ELECTRICAL CONDUIT

Some "balanced rig" advantages on the next page . . .

. . . and IDEAL® drive groups insure smooth power transmission

You'll have the full advantages of a balanced rig when you match integrally designed Ideal Drive Groups with your Ideal Rig. Compact and easy to transport, Ideal Drive Groups are easy to rig-up and disassemble . . . and they provide dependable power transmission under all drilling conditions.

Be sure to get complete details on these outstanding features of Ideal Drive Groups—

Sectionalized construction, with each section a completely self-contained portable unit.

Wide power range, with flexible engine and drive combinations from 200 to 2000 horsepower.

Slush pump drives, available for one, two or more pumps with either single or 2-speed drive.

Three types of transmissions—a choice of mechanical, Ideal Gyrol Fluid Drive or National Torque Converter.

Bulletins on Ideal Drive Groups and Ideal Independent Pump Drives are available at the nearby National Supply Store.

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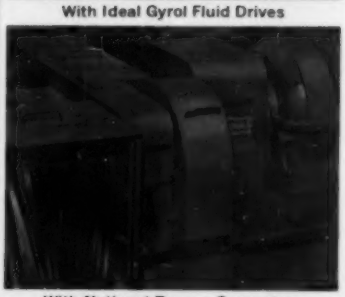
NATIONAL BLUE OIL FIELD MACHINERY AND EQUIPMENT
SPANG STEEL PIPE AND ELECTRICAL CONDUIT

With Ideal Gyrol Fluid Drives



With National Torque Converters

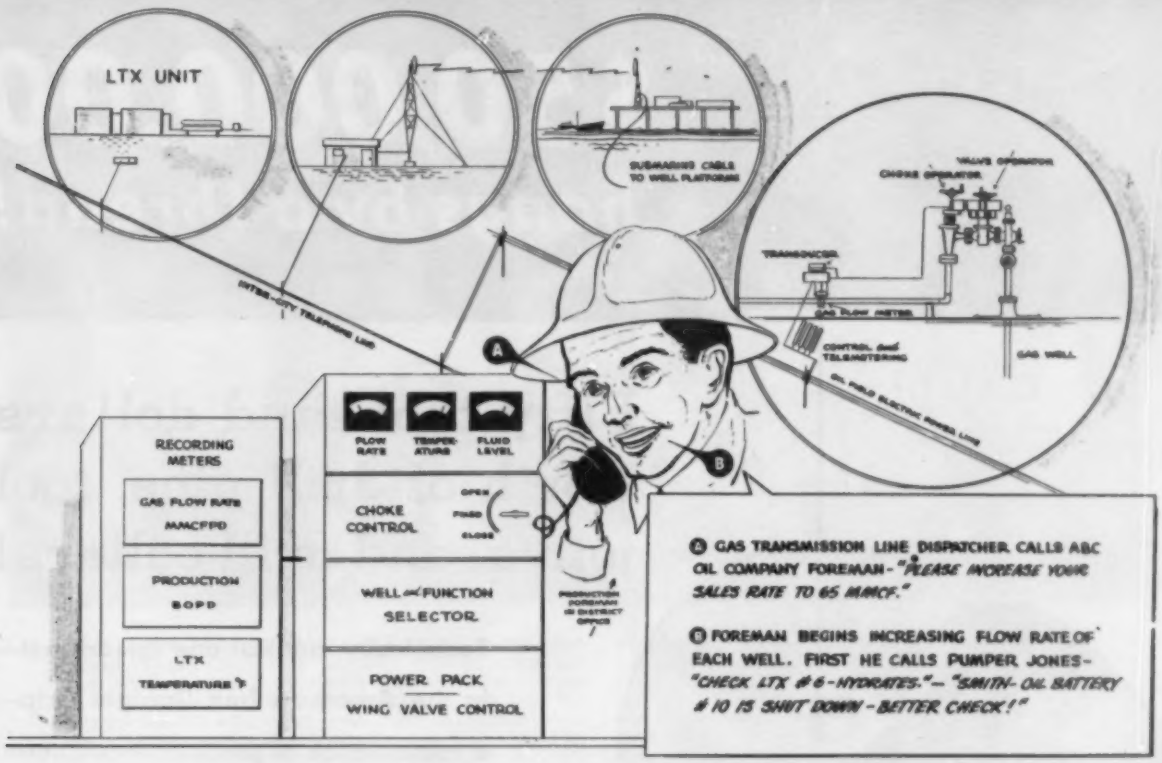


FIG. 1. **Supervisory control and telemetering systems** bring together complete control of oil field production operations, as this diagram indicates.

OIL FIELD AUTOMATION Takes Another Step Ahead

Automatic controls, supervisory control and telemetering systems tie field operations together.

FOR the first time, it is now possible to coordinate automatic lease programming with overall field operations from a central point. This new system incorporates some field-proven ideas in automatic controls and presents several brand new ones in supervisory control and telemetering systems. These systems were designed by McEvoy Company of Houston, Texas, who make some of the major items of control equipment.

Key man in this new system, now being demonstrated throughout the Louisiana and Texas Gulf Coast, is the production foreman. These demonstrations show how it is possible for him to operate an oil and gas field from his field office. He receives a telephone or radio communication from a gas transmission line dispatcher, a gas processing plant superintendent or a crude oil pipe line dispatcher. The nature of this communication is to increase or decrease gas taken from fields under the production foreman's control, or to run a quantity of oil to the crude oil pipe line.

The production foreman looks over his totalized daily production charts as indicated by the recording flow meters and decides which wells or leases should be used to adjust to the flow rate required. He then uses his well selector unit to gain control of a particular well.

As a double check, equipment at the remote point sends back a signal indicating on the control panel that this particular well is now connected and ready to be controlled.

The production foreman then has indicated before him the actual gas flow rate from this well. Next, using a simple toggle switch, he simply causes the well choke to either open or close until the desired flow rate is indicated on the panel meter before him. He repeats this operation for each well requiring adjustment.

His office has control over many other functions at the remote point.

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Fifty thousand dollars worth of drill pipe, tool joints, and drill collars!

Technically, not just one thread, but—in the American Iron Straight Grip—a combination of precision-engineered threads and shrink seals which make the most efficient shrink type tool joint in operation today!

Tests have proven that STRAIGHT GRIP tool joints are 3 times as strong as the pipe they connect!

You may be assured that with STRAIGHT GRIP tool joints on your drill pipe, your string will "hang together" under the most severe drilling conditions.

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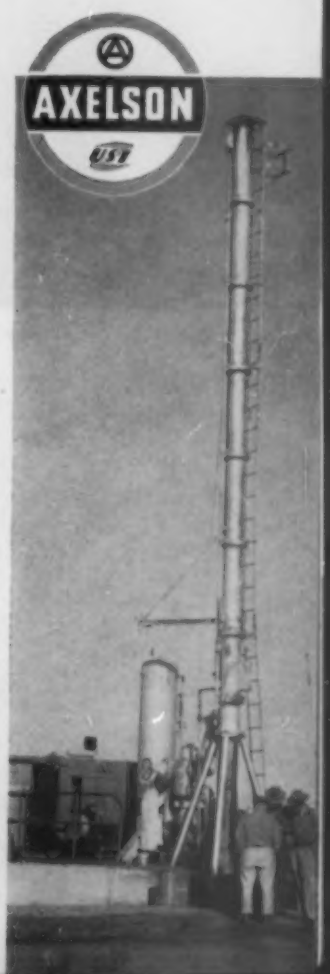
AXELSON PICTORIAL

PROUD FATHERS. This is the backfield for New London High School, Texas. They won the area championship and went on to compete for the state title. In Texas, competition for state honors—well, there's none tougher. The players are all sons of oil men. Left to Right (front row): Jackie Sledge QB, Don Allen FB, Joe Allen HB, Joe Hughes T, Johnny Dickerson QB, Tom McClellan HB, Burna Battles FB. (Back row): Sledge, Humble Oil Company; Allen, Humble Oil Company; Hughes, Sun Oil Company; Dickerson, Humble Oil Company; McClellan, Humble Oil Company; Battles, Atlantic Refining Company. Oilmen also have a championship team in production equipment—Axelson deepwell pumps, sucker rods and hydraulic pumping units.

LEFT TO RIGHT. In front of the Axelson pumping unit (shown at right) are three important members of Leland Fikes' production department: C. W. "Kelly" Lindholm, Lease Foreman; A. D. (Dale) Mortimer, Field Superintendent; Roy Walline, Roustabout. *According to company records, the Axelson unit paid out in nine months.*

960 BPD. This hydraulic pumping unit was installed at Lindsborg, Kansas, May 27, 1951, and was one of the early models built by Axelson. It pumps 960 BPD from 3,300 feet at 6 strokes a minute. A 2¼ Axelson TLE Tubing Pump is at bottom and an Axelson sucker rod string completes the hookup. Axelson Long-Stroke pumping units are recommended for greater production at slower pumping rates, greater depths, less turbulence at well bottom and less wear and tear on subsurface pumps and rods.

TUNESMITH. Making up an RLA pump is Axelson's pump repair crew at the store in Long Beach, California. (Left to right) Bob Campbell, Earl Kirby (Store Manager), Herb Rainbolt. Campbell has written several successful songs for such able performers as Stan Freiburg and others. His latest is "I'll be Kind," recorded at Capitol Records, Hollywood, by a vocal group. Bob is now the new Axelson store manager at Ventura.



A LESSON IN PUMP SERVICE FOR A MAN FROM INDONESIA

Peter C. "Pete" Staats is a Petroleum Engineer for Standard Vacuum Oil Company in Indonesia. The wells under his jurisdiction are in the Lirik Field on the island of Sumatra and although they are presently flowing, they will soon go on the pump. He was born and raised in Holland before his assignment in the Dutch East Indies. Last December he visited the United States to study production techniques in this country, under the direction of D. A. Murphy, District Superintendent for Magnolia Petroleum Company.

At Magnolia's Gunsite Sand Unit Farm near Electra, Texas, Pete saw firsthand how a pump is pulled, repaired, transported and replaced in the well with a minimum loss of time and production. At 9 A.M., the lease foreman called the Jones and Laughlin store in Electra and ordered a pump delivered "right after lunch." The pump in the well was being pulled and was expected to be out just before the lunch hour. The new pump was at the site on time and went back in the well with no loss of rig time. The photographs describe the sequence of events.

IT BEGINS HERE. While the subsurface pump is being assembled in the shop at Jones & Laughlin's store at Electra, Texas, Joe Fitts (left), the Axelson Representative from Graham, Texas, explains the various combinations of Axelson pumps for virtually every type of oilwell service, while Pete Staats (center) and T. M. Bailey, J & L store manager, listen.

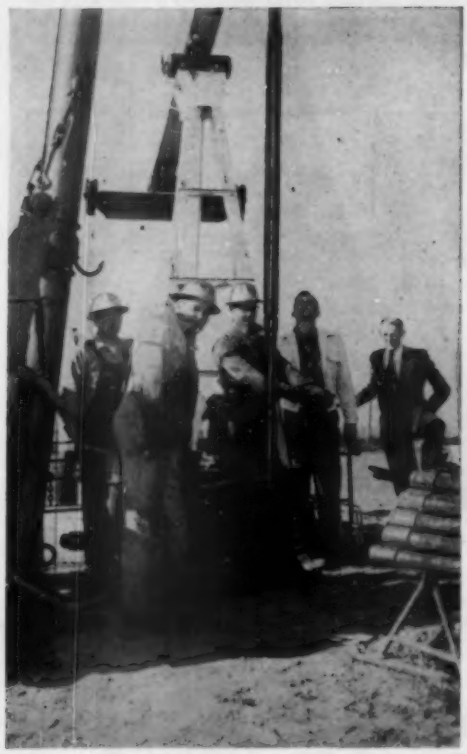
ALL SET. The pump is strapped to the pump rack of Joe Fitts' car by W. E. Cude, Storeman, where it will be delivered directly to the well. Axelson and J & L men carry these car racks for this type of service and it is unusual when they do not put 50,000 miles on a car within a year. They are on call around-the-clock and attend more night and emergency calls than a doctor.

EARLY ARRIVAL. The pump is delivered to the well with time to spare. This is one of Magnolia's portable pulling rigs. Pete meets the members of the crew and listens to their stories while they finish eating lunch. He gathers valuable on-the-scene information he will take back with him to Indonesia.

AXELSON PICTORIAL

OFF SHE COMES. The pump is removed from the car and placed on the tubing rack by three members of Magnolia's well-servicing outfit. Left to right: (lower photo) C. D. Gee, G. R. Walhup, Leroy Cotton. Gee, the gang pusher, has been with Magnolia over 18 years and has handled many an Axelson pump in his time.

MISSION ACCOMPLISHED. The last length of tubing is being made up and the well will soon be on production again. Twenty-six barrels of 40 gravity crude oil are pumped daily from 1,860 feet. Axelson pumps are specially equipped to combat severely corrosive conditions.

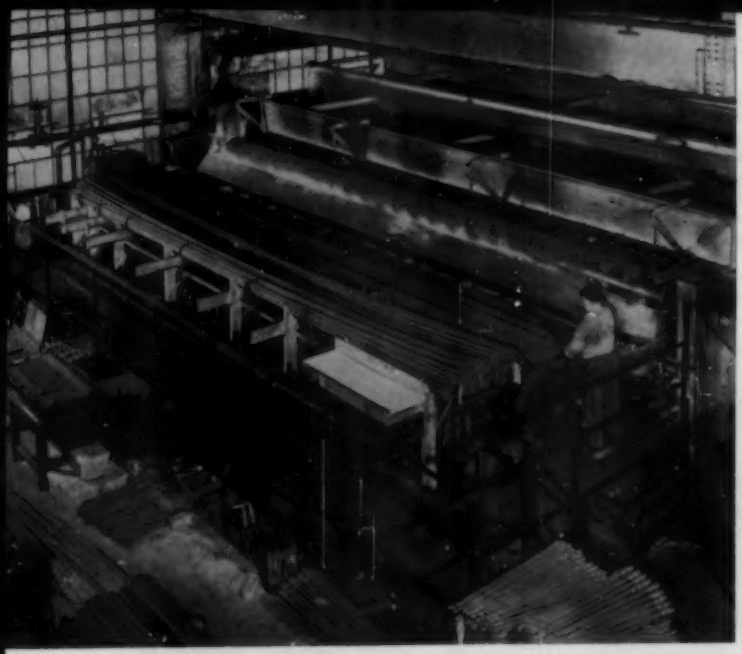


SHORT STROKE. A few miles away near Hollyday, Texas, Pete observes an Axelson Hydrax hydraulic pumping unit in operation for Cities Service Oil Company, while Joe explains its advantages. This is a 6 ft. stroke "Pedestal Mount" Model H100. It is also made with a 10 foot stroke. The Axelson Hydraulic Long Stroke pumping unit (25 ft.) is recommended for greater depths and greater production.

PIPE DOWN. The Axelson pump is being lowered into the well with the first length of tubing while Joe and Pete look on. Joe brought back the pump that had been pulled. The plunger was corroded by electrolysis. New parts were inserted from stock and pump was again ready for active duty.

AXELSON

AXELSON PICTORIAL



16 TONS. ⅞" sucker rods are in process of manufacture at Axelson's St. Louis plant devoted *exclusively* to the fabrication of sucker rods, couplings, polished rods and a complete line of hollow sucker rods. After having been upset on both ends, the rods are ready for heat treatment where all stresses and strains are removed. Axelson was the first to normalize and temper sucker rods throughout their entire length. Axelson was also the first to employ nickel-molybdenum steel in sucker rods suitable for heavy loads and resistance to corrosion.

SANTA FE SPRINGS. Sig Benson (left), Production Foreman for Bandini Petroleum Company, and Mark Ward, Axelson District Manager, smile for the camera in front of the Off No. 9 at Santa Fe Springs. Because of an abrasive condition in this well, the pump was pulled about every four months. After being equipped with Axelson Duax Liners, the pump has been in the well over a year with the same liners (as of January 30, 1956). The Axelson Stuffing Box has also given good service.

HOLLOW VICTORY. R. R. "Rudy" Stafford, District Production Foreman for Pan American Production Company, stands beside a well at Port Barre, Louisiana, equipped with Axelson Hol-O-Rods. Depth 4,833 ft.; production 25 B/D; gravity 36. Because of a paraffin condition, the well was pulled about once a month for cleanup. Now, steam is injected into the well through the hollow sucker rods about every 3 months and pulling is no longer necessary.

No. 2

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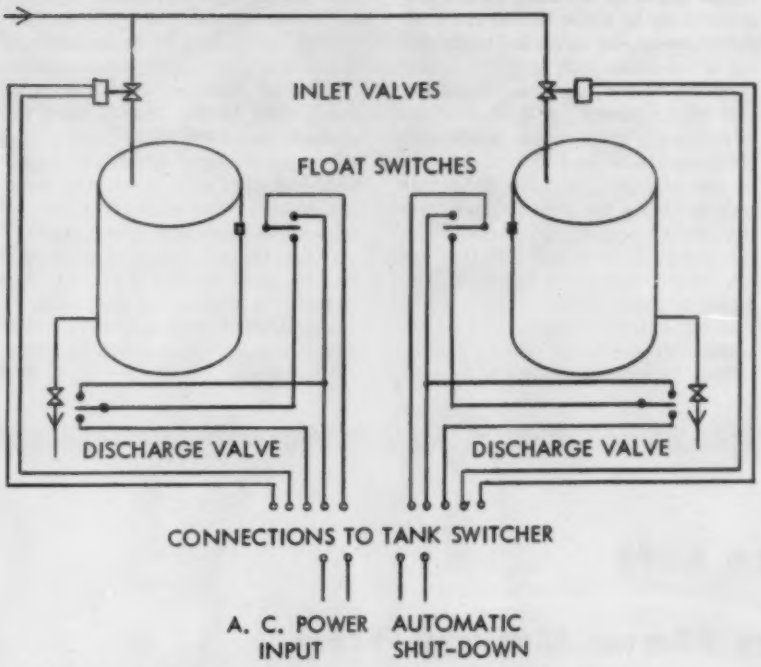
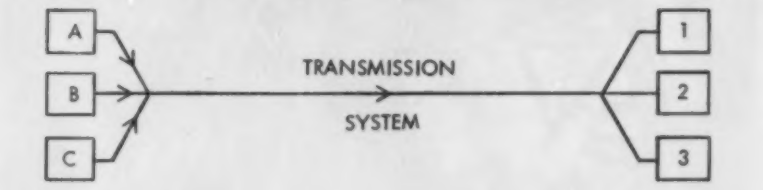


FIG. 2. **External wiring diagram** for two-tank switcher system.



Function 1 is performed only if A and B are sent.
Function 2 is performed only if A and C are sent.
Function 3 is performed only if B and C are sent.

FIG. 3. **Fixed frequencies perform control functions,** and this diagram indicates the principle of operation.

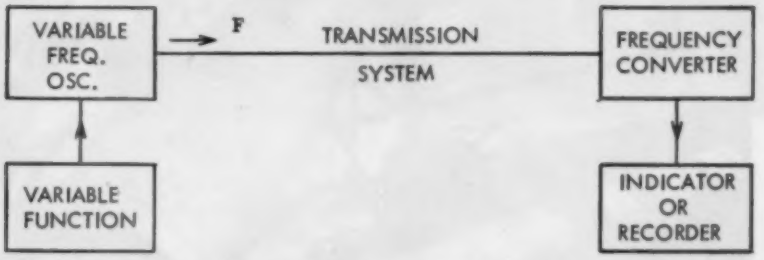


FIG. 4. **Principle used for telemetering** is shown above. F varies proportionally to the variable function. The frequency converter produces a reading and/or record proportional to the frequency and thus proportional to the variable function.

For instance, he may call for and have indicated the temperature of a low-temperature separation unit, oil level in a battery tank or have telemetered to him the well test production data most recently run on that well.

Should the supervisory control circuits go out, automatic battery controls, such as tank switchers, safety shutdown devices and automatic sequence well testing and recording units continue in operation at the remote points. These controls allow normal production under safe conditions and will also telemeter a forewarning or an alarm signal when the battery is shut down for any reason.

The supervisory control and telemetering signals may be transmitted by telephone circuits, electric power distribution systems, or shortwave radio. All of these may be utilized in establisning a control link.

Tank Switchers. Two types of tank switchers provide automatic switching for electrically operated inlet valves on any number of tanks from two to 12. One system was designed for two tanks, and it is shown schematically in Fig. 2. The other system provides controls to electrically switch from three to 12 tanks. The two-tank switching unit also provides visual indications of tank conditions, automatic shutdown in case no tank is available, and switches for manually disconnecting either tank. The switcher requires connections to the upper float switch on each tank, the lower switch on each discharge valve, the inlet valves and the 115-volt supply.

Supervisory control and telemetering. This equipment is designed for applications where an entire voice channel is available or when it is necessary to perform a large number of functions with simultaneous telemetering of the variable functions. Using the frequency band 200-2700 cycles per second, 16 fixed frequencies are available for control functions, and 22 channels for variable functions. The 16 fixed frequencies lie in the band 200-500 cps, resonant reed relays and oscillator controls being used because of their stability and high selectivity. The 22 channels for variable functions cover the frequency range 600-2700 cps and are spaced 100 cps apart.

Two or more fixed frequencies are used for each function, such as control of chokes or valves or any on-off operation, to prevent false operation due to noise or accidental pickup. Fig. 3 is the general basis for this function.

In telemetering, a variable, low-frequency is used, and the function to be metered controls this signal. This variable frequency is then used to modu-

late one of the frequencies in the telemetering range (600-2700 cps). A balanced modulator circuit is used. At the receiving point, selective amplifiers separate the frequencies used for telemetering. The variable frequency is recovered by a balanced detector and is then used to control a meter movement. The meter is calibrated to give readings of the measured variable. Any function capable of producing a mechanical motion can be telemetered. Fig. 4 shows the telemetering principle.

Power lines can be used. Where the are no telephone lines or separate wires available for control and telemetering, a system has been designed to utilize power lines to the well head for these functions. The power lines transmit the signals required. By using carrier frequencies up to about 10,000 cps, control of chokes and valves and telemetering of variables such as pressure and temperature are easily accomplished.

A low frequency signal which varies in frequency proportional to the variable function is used to modulate one of the carriers. This carrier is then transmitted to the central point over the power lines. At the central point, the carrier is amplified and then the low frequency signal is recovered. This signal is then converted to a meter reading which is proportional to the variable function. By correct calibration of the meter, the variable function may be read directly. This method is used for each of the variable functions to be telemetered. The variable function or functions may be indicated as required and/or recorded continuously.

Control of chokes and valves is accomplished by the use of fixed frequencies in the low audio range. Either off-on operation of a valve or adjustable operation of a choke may be accomplished in this manner. In order to obtain minimum false operation, three separate frequencies are used to control the choke or valve. A normal off-on switch is used for valve operation, but the choke is controlled by a three-position switch, spring loaded to the center-off position. ★ ★ ★

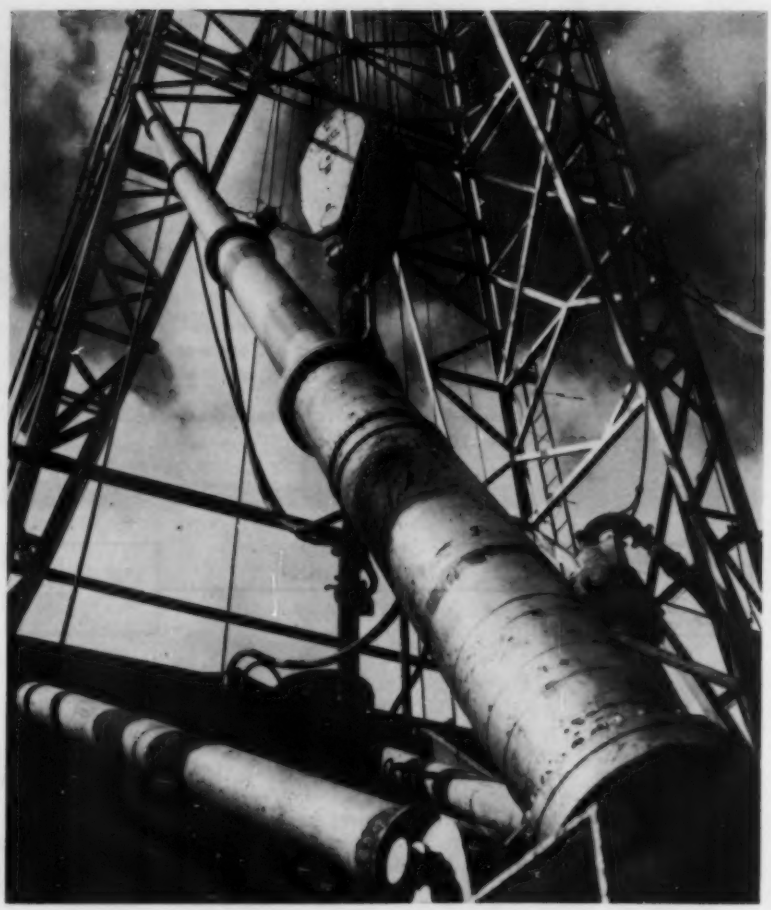
Hydraulic Jacks Lift 132-ft Mast on New Barge Rig

Hydraulic lifting of the derrick on Ward Drilling Company's new inland drilling barge has proved to be an important and most successful safety aid to the firm's first step into marshlands operations.

The Baton Rouge, Louisiana, company has completed the first marshland well with its new Rig No. 1 near Venice, Louisiana. The barge-mounted unit is designed to drill a 13,000-ft well. The barge measures 165 ft in length, 46 ft wide and almost 11 ft deep; it has an 85 by 10 ft slot.

The 132-ft derrick is raised and lowered by means of two hydraulic jacks. This method of raising the derrick, instead of relying on the drawworks, lends to greater control and safety. The jacks are located forward of the superstructure and are operated by pressure built up by individual hydraulic pumps. The pump is an independent system and is also used to operate the hydraulic slips and tongs.

The drawworks is powered by diesel-powered units developing a combined total of 1200 hp. The rig also has a 145-hp coring unit. The 27½-in. rotary is independently driven from a 390-hp engine. The two mud pumps are driven from engine compound.



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Salient features of modified "In-Situ" method include:

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- **Some formation oil burned to develop additional heat**
- **Free oxygen added by gas-steam mixture**

Richard Garbus
Worthington Corporation
Harrison, New Jersey

A new idea involving the thermal principle of oil recovery is being field tested by Forest Oil Corporation in cooperation with the Worthington Corporation in the Parker Pool of Clark County, Illinois. Design of equipment as well as the field tests are under the direction of H. Walter, director of research for Worthington.

This new process is based on the idea of heating the oil-bearing formations by the injection of hot gas-steam mixture. As the temperature of the sand increases, viscosity of the oil decreases. Driving gases, introduced at injection wells, move the hot oil, now having a low viscosity, to the producing wells, where it is brought to the surface.

Basically, all the heat required to raise the temperature of the formation could be developed by surface equipment. It is economically advantageous, however, to burn a fraction of the crude directly in the formation to develop the heat "in place." At temperatures considerably less than 400 F, it was found that if some free oxygen were present, combustion of the crude in the formation starts spontaneously. Therefore, all that is necessary to start the combustion "in-situ" is to add free oxygen to the injected steam-gas mixture.

Need for Method

Only about 50 per cent of the original oil content in an oil field is recovered by known primary and secondary oil recovery methods! This percentage varies, of course, ranging from close to 100 per cent recovery in condensate fields to almost 0 per cent in fields containing highly viscous oil.

In 1953, it was estimated that the total domestic oil reserves in the United States were 33 billion barrels and that the "unrecoverable heavy crudes" were in excess of 4 billion barrels. These figures indicate why processes are being developed to produce this "unrecoverable" oil.

Of the processes presently tested, the most promising appears to be the thermal secondary oil-recovery methods. Their application, however, is not necessarily limited to heavy crude fields. Even where usual secondary recovery methods, like water flooding or gas injection, are economically successful, considerable amounts of crude are left in the reservoir. If economical techniques of thermal recovery are developed that give higher ultimate recovery rates, they will, in many instances, replace the known secondary methods.

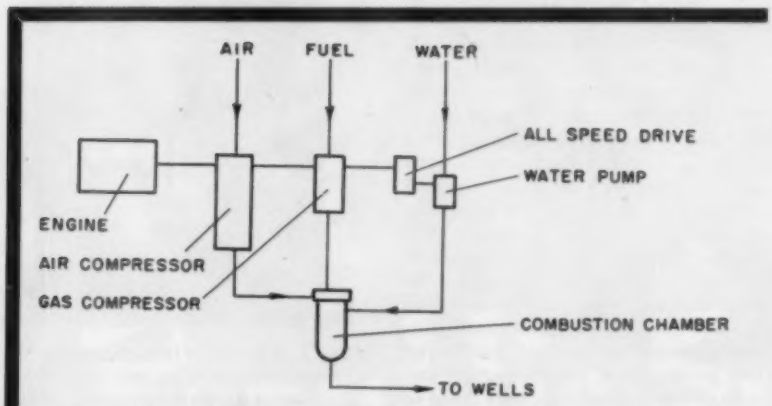

FIG. 1. **General arrangement of plant components** used in the modified "in-situ" method of thermal oil recovery now under test in Illinois.

Three Basic Zones

As the thermal process becomes effective, three basic zones appear around each injection well. The first zone has been completely depleted of its oil content. A gas mixture containing free oxygen is continuously driven through this zone, but no reaction can take place since no combustible matter is available.

The second zone is the combustion zone. The formation has been heated to or above the ignition temperature. Injected gas mixture containing free oxygen passes through this zone. Since some hydrocarbon matter is still present, a reaction takes place and the hydrocarbon matter burns. Generally, the temperature in this zone is about equal to the evaporation temperature of the heavy fractions of the crude.

In the third zone, the formation temperature has not yet reached ignition temperature. Therefore, no reaction can take place here, although enough hydrocarbon matter is available. Even if the gases driven through this zone do contain some free oxygen, it will pass without reacting and act as a heat-carrying medium only.

Power Plant

Purpose of the test was to investigate the various processes, and find

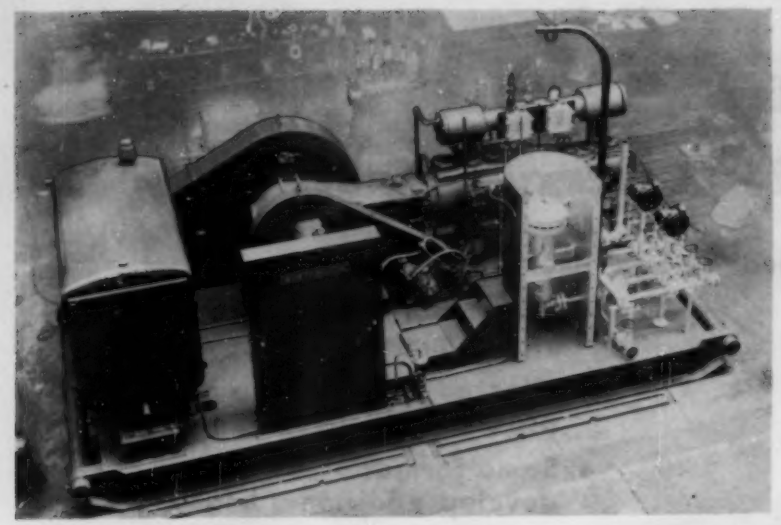

FIG. 2. **Plant equipment mounted on skid** includes 150-hp engine, air compressor, gas compressor, water pump, combustion chamber and controls.

best conditions for economical oil recovery. Therefore, the composition and temperature of the injected mixture had to be changed in a wide range and the power plant had to be designed to meet these changing operating conditions.

Fig. 1 shows the general arrangement of the components of this new system while Fig 2 is of the plant itself.

The plant consists of an air compressor, a gas compressor or fuel pump, and a water pump, all of which are driven by a 150-hp gas engine. Compressed air and fuel are injected into the combustion chamber (Fig. 3), where the fuel is burned at high temperature. Water first serves as a chamber coolant and is then directly injected into the lower part of the chamber, producing a steam-combustion gas mixture. This mixture flows directly to the injection wells.

Here is the capacity of the plant and characteristics of the produced mixture:

Capacity:	400,000 scf per day of air; 55,000 lb per day of gas-steam mixture.
Pressure:	Up to 500 psi.
Temperature:	350 F to 900 F.
Composition:	Can be varied from pure air to a mixture of combustion gas and steam. The amount of free oxygen can be varied from 23 to 0 per cent by weight.
Fuel for Combustion Chamber:	Natural Gas, propane, or oil.

Test Site

The Parker Pool in Clark County, Illinois, was selected as the test site. The thickness of the sand was 35 ft at a depth of approximately 275 to 310 ft. The characteristics of the sand and crude as found by laboratory analysis were as follows:

Average weighted porosity	20 per cent
Average weighted permeability	400 to 700 md
Average total water saturation	27 per cent
Average oil saturation	45 per cent
Total oil content	24,000bbl per acre
Gravity of crude at 60 F	26.3 API
Viscosity at 100 F	178 SUS
Initial boiling point	335 F

Test Wells

When the Parker Pool was opened in the "Twenties," the sandstone formation showed little natural production, but numerous wells had been drilled through into the deeper limestone. Also, water drive tests had not been successful.

A plot showing the location of the test wells is presented in Fig. 4. The two center wells (designated as the East Well and the West Well) were drilled first, while the four corner wells (NE, NW, SW and SE Wells) were drilled after the tests were begun. After the tests were completed, wells No. 1 and No. 2 were drilled for coring only.

Piping to and in the injection wells was insulated with asbestos. Thermocouples were installed in the bottom of all production wells. No pumps were used to extract the produced liquids to the surface. Fluids were lifted by the produced gas, which had been driven through the sand. The produced liquids were collected in a manifold and flowed to a gas separator, water separator and storage tanks. Provisions were made so that, if desired, production of each well could be measured separately.

The Tests

Preliminary tests were begun in September, 1953, with the two center wells placed 30 ft apart. A steam-gas mixture was injected into the East Well. Approximately two weeks later, the West Well was beginning to produce steadily some gas, oil and water. Temperature in the West Well slowly rose to 90 F in December, and rather suddenly in January, it rose to 220 F and higher. It remained at that level until the well was shut in.

Oil production from the well also increased rather suddenly, from less than 1 bbl per day in December to approximately 8 bbl per day in January, 1954. It remained at that level until March, and then decreased until the well was shut in, in April, 1954.

All four corner wells reacted similarly. A rather sudden increase in the temperature of the well occurred simultaneously with an increase in oil production. From then on, the wells produced at high rates. The gas production kept on increasing, but the production of oil decreased after some time, and the wells were shut in.

The production history of the test is shown in Fig. 5. The four corner wells were drilled and connected in Decem-

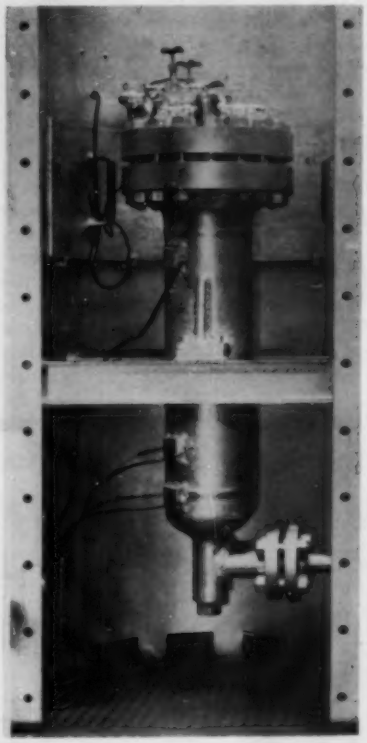

FIG. 3. **Combustion chamber** receives compressed air and fuel, which is burned at a high temperature. Water is also injected in the chamber to make the gas-steam mixture.

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ber, 1953, and January, 1954. The wells heated up from October, 1954, to April, 1955. The test was stopped before the SE Well had heated to quite the same degree as the other wells. As soon as the tests were started, a non-uniformity (anisotropy) in the permeability of the sand was observed. This is one reason why all the wells did not heat up simultaneously. Another reason was disturbance by an experimental water flooding operation to the south of this test, which hindered gas flow to the SE and SW Wells.

An injection pressure of 350-400 psi was estimated as safe, and was maintained throughout the test. The mixture temperature was varied between 400 F and 900 F, with lower temperatures being applied during the latter part of the test.

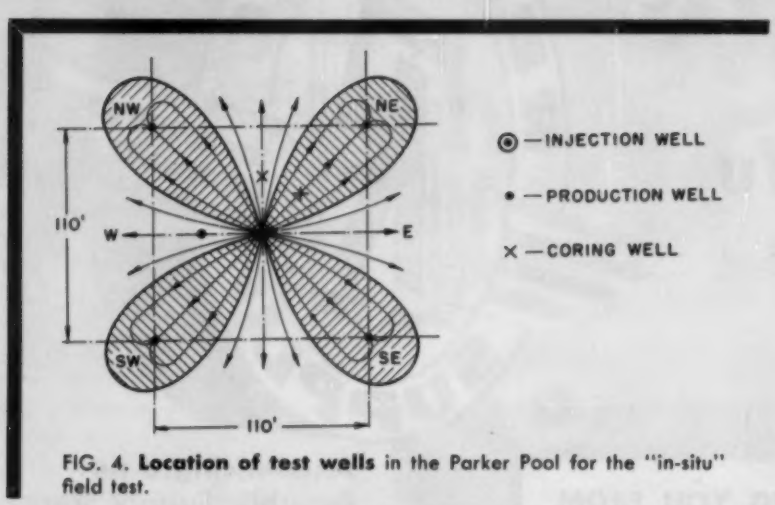

FIG. 4. **Location of test wells** in the Parker Pool for the "in-situ" field test.

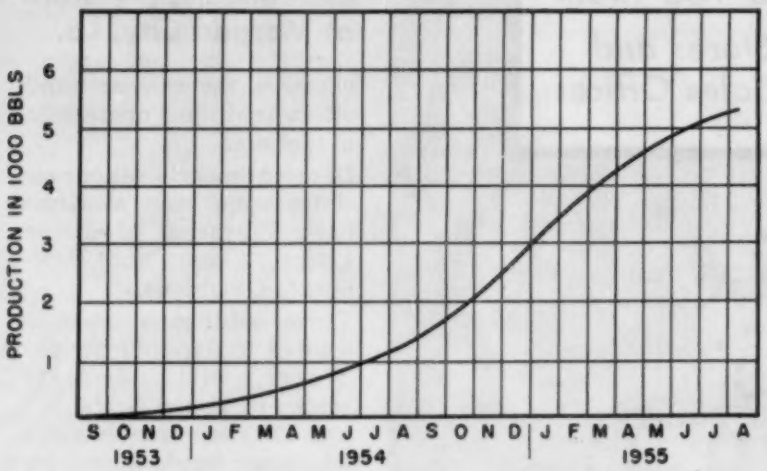

FIG. 5. **Cumulative oil production** covering nearly two years field testing this new thermal recovery idea in the Parker Pool.

FIG. 6. **Production rate in unit volumes per day** over the test period.

Mixture Varied

Composition of the injected mixture was varied in a wide range. Almost no oxygen was injected in the beginning. Air was injected on only two occasions over periods exceeding one month. The average composition of the mixture over the duration of the test was:

Steam	40 per cent
Nitrogen	47 per cent
Carbon Dioxide	6 per cent
Oxygen	7 per cent

Basis for Practical Development

Please note here that the production curves of Fig. 5 and 6 are influenced and distorted by the unsteady operation conditions and by several shutdown periods.

Approximately 50 per cent of the injected dry gas was recovered from the production wells, but the remainder escaped into the field. Therefore, the area from which oil was produced has a shape as indicated by cross-hatching in Fig. 4. It was calculated that this area is approximately equal to the area of the square between the four corner wells or 0.277 acres.

A total amount of 5210 bbl of oil was produced by all wells and sold; another 90 bbl were on hand in tanks after the tests were completed. Oil losses due to evaporation, leaks, and other reasons were estimated to be 3 per cent of the total. This is equivalent to a production rate of 19,000 bbl per acre or to 80 per cent of the original content — a very remarkable result especially considering the tests were discontinued while the wells were still producing, and that approximately 10 per cent of the original oil content had been burned underground. Analysis of cores from wells No. 1 and No. 2 confirmed these figures.

A Technical Success

Besides the very high oil-recovery rate that was achieved, enough information was obtained from the test to indicate what injection mixtures will produce the best results and how the recovery process has to be conducted to be economical. All indications are that a project on a large scale (100 acres or more), with improved equipment, would be financially successful. ★ ★

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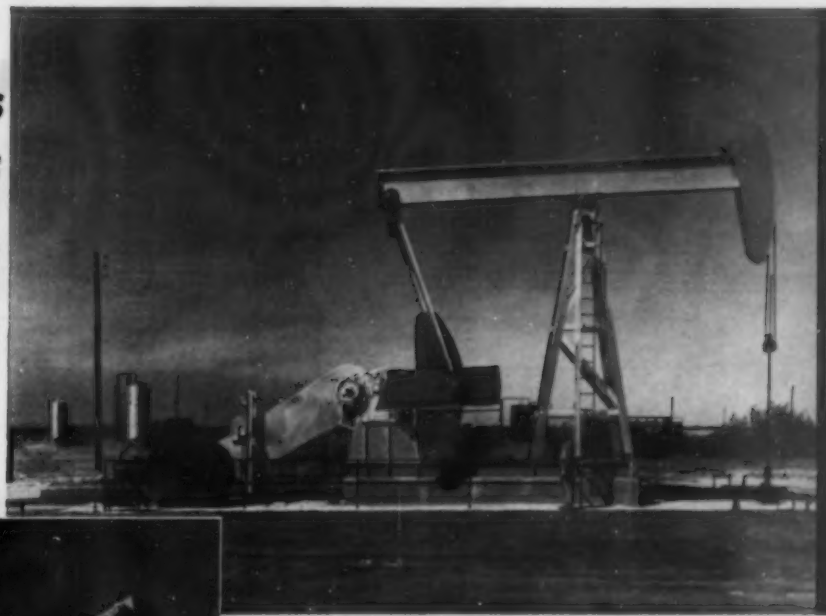

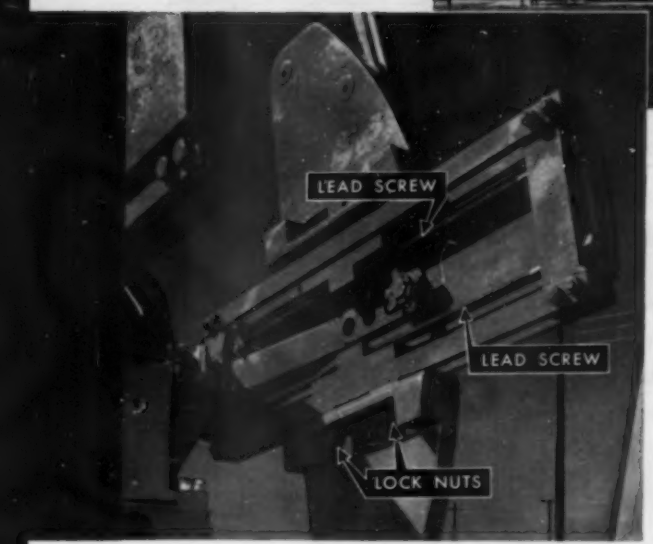

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These new long stroke pumpers by Parkersburg are not an adaptation of smaller pumpers, but specifically engineered units for long stroke, deep-well pumping. They have all of the proved design and construction features which have made Parkersburg Pumpers leaders for almost sixty years.

In addition to stronger, heavier construction they have such improvements as equal working centers; improved one-man crank counterbalance and short base mounting for any type engine or electric motor.

Parkersburg Long Stroke Pumpers are available in 120″ and 144″ units. Each has a beam capacity of 32,700 lbs. The 120″ pumper has a peak torque rating of 456,000″ lbs.; the 144″ unit a peak torque rating of 640,000″ lbs.

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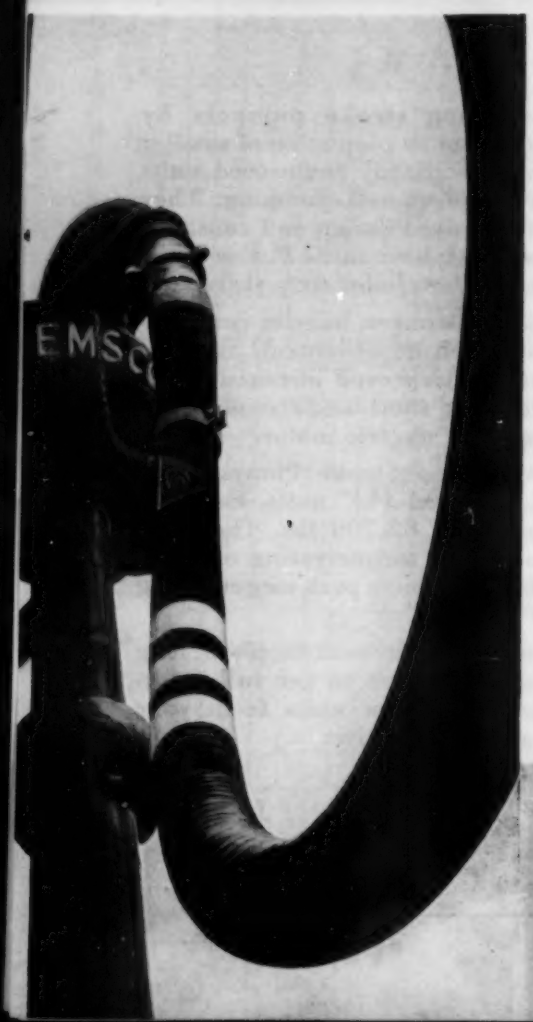

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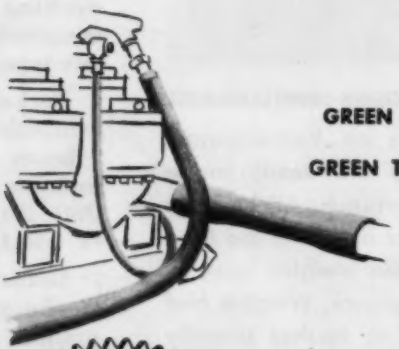

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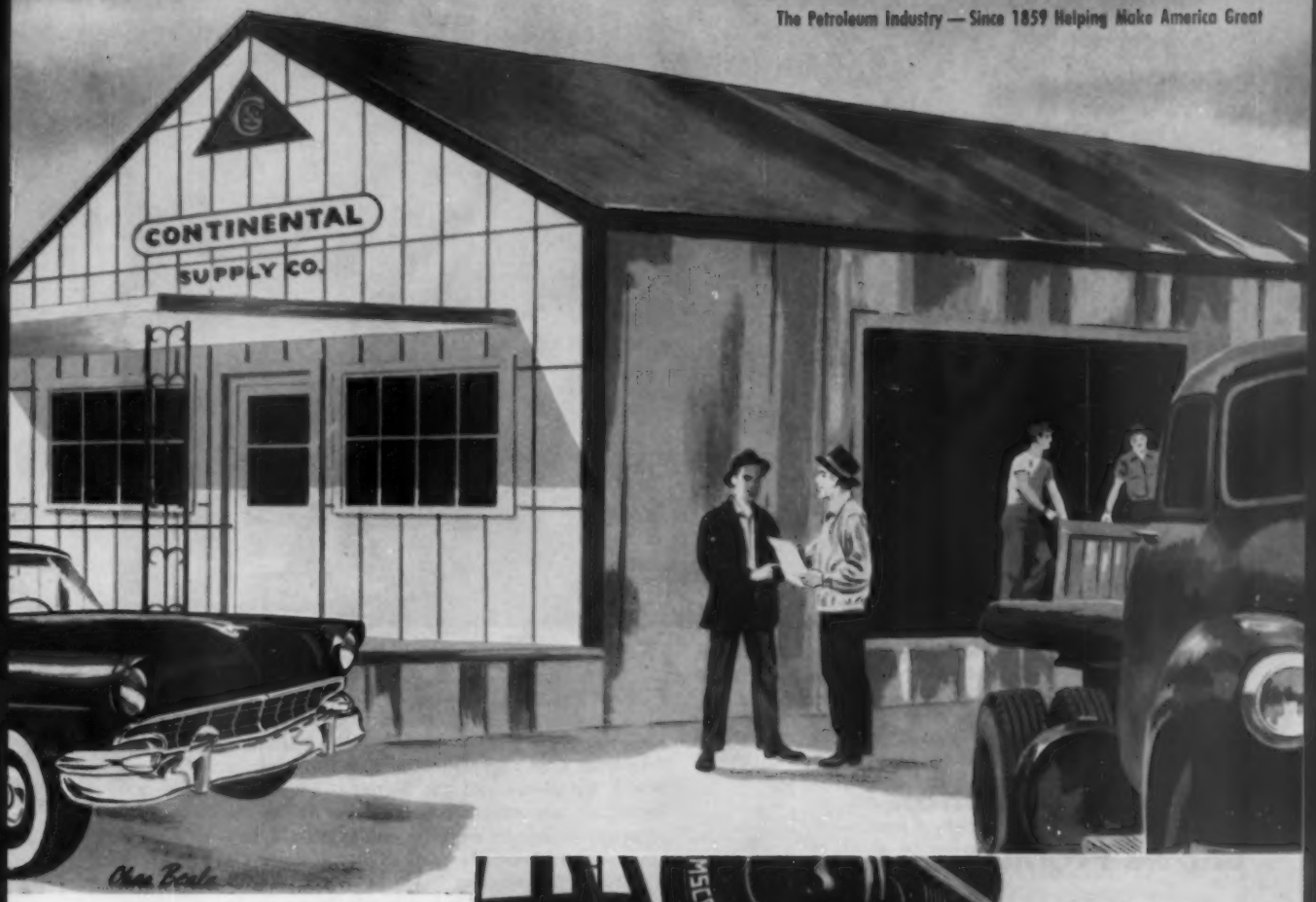

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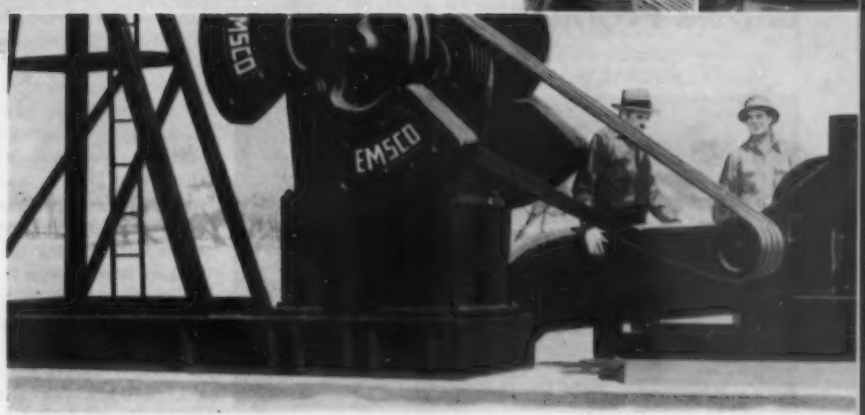

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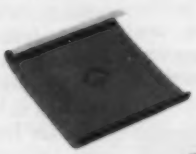

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Omati well site and, in the foreground, the Australian Petroleum Company camp. Natural gas found here is the first success in over 40 years of Papua exploration.

Papua Exploration Shows Promise

Transportation is one of the biggest problems in the Papua oil research. Native canoes, like those above, are used to suply seismic survey camps. This D'Arcy Exploration Company helicopter, below, is used to speed communication through the dense jungle.

FORTY years ago, exploration for oil started in Papua, the Australian-owned south eastern part of New Guinea. Until a few weeks ago results were negligible. Then the Australasian Petroleum Company — jointly owned by Standard-Vacuum, British Petroleum and Oil Search — announced that a gas show had been encountered at Kuru, one of the three wells presently being drilled. The company said that substantial gas had been found at a depth of 998 ft; it was escaping at the surface behind a casing which had been recently cemeted at a depth of 449 ft. The hole was now being put in satisfactory condition and formation tests would be carried out. Kuru is located north-east of Omati in jungle country. Its only means of access is a river about seven miles away. To bring in rig and equipment a road had to be built through the jungle from the river. Due to torrential rainfall this job alone took 17 months instead of the usual few weeks. Now it seems this enterprise is paying off.

Exploration for oil in Papua began on a major scale just before World War II. Two companies are operating in the territory, Australasian Petroleum and Island Exploration; both are U. S., British and Australian owned. By the middle of last year they had spent $36,000,000 on exploration and another $15,000,000 had been scheduled for operations expected to last well into 1957. Nine dry holes have been drilled so far, three were abandoned last year alone. Among them were the two wells at Omati — one of them started in 1950 — which were given up at depths of 14,352 ft and 10,880 ft respectively. At Aramia, 120 miles west of Omati, drilling began in April 1955, reached a depth of 5500 ft by the summer, and had to be given up as dry in November.

Apart from Kuru, where gas has now been encountered, two wells are presently being drilled in Papua. They are at Barikewa, north of Omati, and in the Morehead area south of the Fly river in south-west Papua. Inhospitable jungle and swampy terrain are hampering operations in this territory. Biggest problem is transportation. Helicopters are used extensively to carry food and stores but, of course, they are unable to carry heavy equipment and drilling gear to isolated sites. In some cases, such as Kuru, it was necessary to construct special roads, usually it has been possible to move heavy supplies by river. Specially designed landing craft have been built in England, each capable of carrying 120 tons of equipment, including drilling gear, bulldozers and piping.

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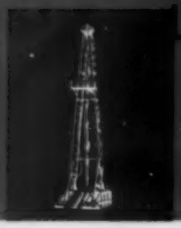


published for the busy oil man by Lane-Wells Co. — one of the Dresser Industries

L-W RADIOACTIVITY LOGGING GIVES QUANTITATIVE RESULTS

Quantitative analysis in many forms of logging operations has long remained a dream. Now comes an awakening, as Lane-Wells Radioactivity logging opens an ever-widening way to accurate determination of formation characteristics by wire-line methods.

For some time operators have been able to predict porosity in carbonate reservoirs from Lane-Wells Neutron curve with extremely close correlation to results obtained by core analysis.

Now Lane-Wells engineers have expanded this application to include a method of evaluating porosities in sands and shaly sands with an accuracy well within the need of practical requirements. For instance, in one well this procedure showed the average porosity for an entire zone to be 17.8%. Core laboratory figures for the same zone showed 18.1%, a difference of only .3%!

So far this method has not been applied to all areas, but it has proved itself in such oil country as the Denver-Julesburg Basin, the Green River Basin, the Powder River Basin, the San Juan Basin, the Big Horn Basin, and the Cuyama Valley. Little doubt remains that the method will prove valid from a practical standpoint in many other areas as well.

Reproducible accuracy makes possible the ability of Lane-Wells Radioactivity logs to be used as a quantitative analytical tool. From the standpoint of the laboratory analyst, the ability of any given device to reproduce results exactly under identical conditions is the strongest measure of its accuracy and reliability. This the Lane-Wells Radioactivity logs can accomplish without equal. And when one considers the remarkable sensitivity and detailed delineation of the curves recorded by this process, that, indeed, is a remarkable accomplishment.

The time has not yet arrived, of course, when a wire-line tool can produce an accurate prediction of productive capacity, gas-oil ratio, pressure decline and a host of PVT data. But consider this: By means of such tools as the Lane-Wells Radioactivity log, the operator now can obtain by wire-line more accurate downhole information than could his fellow of a few years ago employing more cumbersome empirical methods.

To obtain the most complete picture in the quickest possible time, operators can run Lane-Wells Gamma Ray and Neutron logs simultaneously. This Dualized logging gives the operator as complete a sub-surface picture as can be coaxed through a length of cable in one operation. Dualized logging retains all the important characteristics of both phases of Radioactivity logging. The simultaneous curves equal or better the individual curves in all respects and the running time is cut in half. Operational procedures remain essentially the same for both types.

As in other types of Lane-Wells logs, the collar log forms an integral part of the Radioactivity log, making it a simple matter to orient wire-line measurements to casing.

There are many more reasons operators have ordered Lane-Wells Radioactivity logs by the tens of thousands. Check F-1 on the attached card to learn all about them.

WANT MORE INFORMATION?

More information on items here will be sent to you gladly on request. A code number appears at the end of each article. For additional information about that item circle that code number on the reply card at the bottom of page 3. Just mail the card — we'll pay the postage.

CORGUN GETS CORES WHILE THEY'RE HOT

Cores, like news stories, have to be "hot" to be valuable. Yesterday's news and hours-old cores have little informative value. The Lane-Wells Corgun gets cores to the surface while they are still newsworthy to the geologist and production engineer.

Speed alone, however, does not guarantee representative cores. But when wire-line speed combines with other Lane-Wells core - protective measures, the resulting cores arrive at the derrick floor—by wire—brimful of significant data.

In the first place, the core extraction method reduces the chances of contamination to a minimum. The Corgun fires the core barrel into the formation and encloses the core instantly without a prolonged interval of exposure to well fluids.

Secondly, only the Lane-Wells Corgun core barrel eliminates the shattering ram effect of closed-end barrels.

Thirdly, and maybe most importantly, the Corgun gets the cores you want from the region in which you want 'em. Why? Because zones for coring are chosen on the basis of wireline measurements; i.e., Electrologs, Radioactivity logs, etc. It follows then that a coring system run on a wire-line will correlate better than one run on tubular goods. Elementary, what? Of course, to really tie the cores to a hairline zone, simply run the Corgun in tandem with the Electrolog. When the curves match, the Lane-Wells operator touches off the Corgun, and in a matter of minutes you have the cores in hand—by wire.

Checking F-2 on the attached card will bring you more information about the Corgun.

THRU TUBING COMPLETIONS SAVE DAYS OF RIG TIME

Dismissing the drilling rig before the well is brought in, or the cement has set, was just another impossibility a few years ago. Which meant that the operator had to pay for days of standby time, with nothing he could do about it.

But today Lane-Wells Thru-Tubing completions offer a convenient means of curtailing dead rig time. Because, with special Lane - Wells equipment and personnel on the job, wells can be logged and perforated safely, speedily, and accurately without a drilling rig after tubing has been set.

There is nothing makeshift about this equipment. Four different types of Koneshot perforators are available, including the powerful Swing-Jet which is housed in a 1¾" O.D. carrier. But in the horizontal shooting position this gun has an effective O.D. of 4⅜", thus permitting the use of a heavy explosive charge.

Two sets of Radioactivity logging instruments are available, one in 1¾" and the other in 1⅜" sizes. For all practical purposes, the curves from these two miniaturized down-hole tools correlate exactly with those of their big brothers.

And certainly there is nothing makeshift about the Lane-Wells crew and surface control equipment either. The first is especially trained for this type of operation and has had plenty of experience in putting it into effect. The second, from control truck to well head, has been built for this one job. So, to realize the full benefits of Thru-Tubing completions, obtain this service from Lane-Wells, the one service company that can provide the equipment and personnel for the whole job.

Check F-3 on the attached for more information.

ABSTRACTS—CURRENT AND PERTINENT

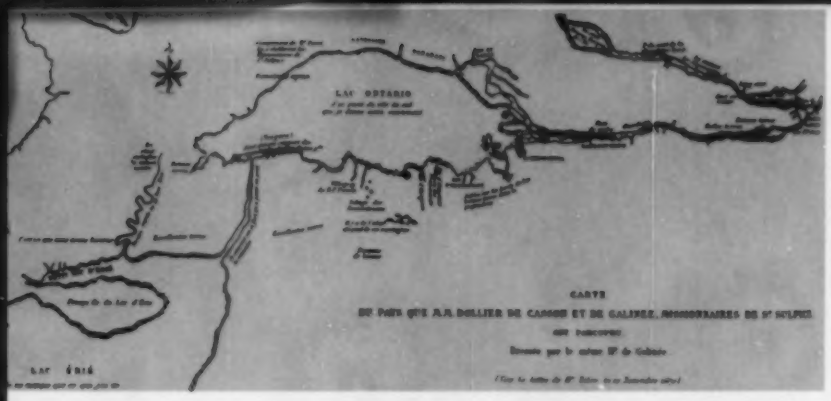
WEST TEXAS GETS NEW FIELDS As Cambrian sands prove out as reservoirs. Pre-Ellenburger rocks add millions of barrels to reserves at comparatively shallow depths. Study gives Radioactivity correlations in key wells. F-4
"Cambrian Production Opens New Trend in West Texas," by Aaron W. Cook, p. 99, World Oil, Nov., 1955.

NOW IT'S BACTERIA That might point the way to new oil discoveries. Abnormal quantities of methane-oxidizing bacteria in subsoil overlying known oil deposits hint of new exploration procedure. F-5
"A Microbiological Method of Prospecting for Oil,"by Dr. R. J. Stawinski, p. 104, World Oil, Nov., 1955.

THIN-HOLE DRILLING Offers possibilities of major savings but embodies heavy problems. Equipment is small, mobile, material- and labor-saving. But stuck tools and slow drilling rates prove troublesome. F-6
"Will Ultraslim-Hole Drilling Pay Off?" by D. H. Stormont, p. 92, Oil & Gas Journal, Oct. 31, 1955.

"HOW'S THE AIR DOWN THERE?" May be the next inquiry about drilling mud in the well. Mud alone was used for years. Then came the trial with straight air. Now a mixture of mud and air has proved to have many advantages over air or mud alone. F-7
"Aerated Mud Drilling," by Roy A. Bobo, R. S. Hock, George S. Ormsby, p. B-46, Petroleum Engineer, Nov., 1955.

CONFUSED WELL HISTORIES Are straightened out by Radioactivity logging. Before water flooding an oil field, operators applied modern logging methods to provide a clear sub-surface picture. F-8
"Radioactivity Logs Help Solve Water-flood Problems," by N. J. Mellies and C. W. Clark, p. 4, TTT, 3rd q., 1952.



FIRST AMERICAN OIL MAP?

This ancient map, prepared by a seventeenth-century French missionary, shows a "Fontaine de bitume" somewhere in New York or Northern Pennsylvania. This may be the earliest map indicating an oil location in the U. S.

PACKERS HAVE IMPROVED SINCE THE SEED BAG

The sack of flaxseed tied to the end of a string of tubular goods had to serve as a packer in grandpa's day. If everything worked right, the water in the well swelled the seed to shut off the annulus — just like a four-horse parlay.

The system spoke highly of the old timer's ingenuity to make do with the materials at hand. But its reliability left a lot to be desired. Packers improved, of course, and now they are better than ever. But for a time the trend seemed to be toward making them bigger and more complicated — and more expensive.

Some bright engineer (Lane-Wells on the job again) figured that most jobs of acidizing, pressurizing, fracturing, water flooding, and the like did not need something with 117 moving parts which, when they all worked, would withstand pressures that would tear the casing to shreds. All this, of course, with a price tag to match. He figured that a simple, reliable packer, economically priced, would do most jobs of packing off, without the need of hauling out to the field a design-engineer's display piece with all its attendant hardware.

Hence, the T.O.P. Packer.

The T.O.P. Packer has proved reliable, effective, safe, and economical on hundreds of jobs in the short time since its introduction. It sets easily, holds firmly, and retrieves reliably. It has enough built-in safety features to satisfy the most suspicious toolpusher.

The T.O.P., of course, stands for Tension Operated Packer, which provides quite a story in itself. Lots of packers set by applying weight to the tubing, but guessing the right amount of weight doesn't come easy, particularly with short strings. Much more exact, predictable, and controllable is the setting of the T.O.P. by pulling UP on the string after turning to the right about 10 revolutions.

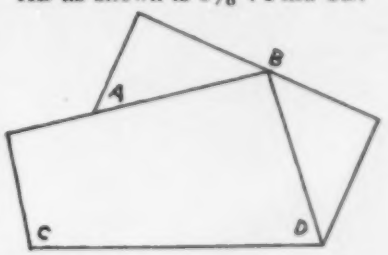
The T.O.P. retrieves with equal simplicity. Simply lower the tubing string to unlatch the slips and haul it back aboard. Obviously, nothing in this operation would strain the capabilities of any drilling crew.

While Lane-Wells engineers advocate the use of the T.O.P. against bottom-hole differential pressures up to 3000 psi, the tool can be used for high-pressure squeeze and fracturing jobs if the annulus is suitably loaded. Otherwise such a job calls for the packer equivalent of Big Bertha.

Check F-9 on the attached card for more data on this common-sense tool.

SUPER BRAIN BREAKER

A piece of paper 8½" x 11" is folded once as in the accompanying diagram. The length of AB as shown is 5⅝". Find CD.



ANSWER TO SUPER BRAIN BREAKER IN LAST ISSUE: Diameter of the large circle is 64.64".

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new "balanced" powder gives 21% greater bullet penetration

That 21% greater bullet penetration is a conservative – mighty conservative – figure! Because it's the bottom figure from a series of tests run by a major oil company for their own information. These tests showed from 21% to 28% greater bullet penetration than could be achieved with Lane-Wells #3 powder – and that was powerful powder, as the same tests showed. Lane-Wells new #7 powder is a new answer to the age-old ballistics problem of how to get more power behind the bullet without increasing the strain on the gun. #7 has been so formulated and "balanced" that it burns slower, with lower peak pressure, but *longer*...thus building up a tremendous "push" behind the bullet that drives it deeper into the formation. And there's no price premium for #7 powder – just another example of Lane-Wells efforts to give better service.

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CALIFORNIA

Attention: Advertising Section

Tomorrow's Tools – Today! ®

Training, oil emulsion muds, drill collar replacements reduce Creole's

Fishing Operations in Venezuela

Average time spent per job in 1951 was 7.5 days; in 1955 average cut to 1.3 days per fishing job

R. W. Beck
Creole Petroleum Corporation, New York, New York

RECENT improvements in reducing the amount of time spent on fishing are attributed to increased use of oil-emulsion muds, the replacement of overage and worn out drill collars, and to the results of drilling training programs. These conclusions are borne out by a statistical study of 7½ years of fishing operations by Creole Petroleum Corporation in Venezuela.

General

The Creole Petroleum Corporation has all of its operations within Venezuela. Creole's drilling problems are those common to foreign operations, and they may differ considerably from those experienced in domestic operations in the United States. One major difference is that Creole regularly performs 75 per cent to 90 per cent of its drilling with company tools as compared with the much wider use of drilling contractors by producers in the States. Another problem related to foreign operations is the lack of specialized fishing services, which means that all of Creole's fishing jobs have to be handled directly by the regular drilling personnel. Other problems relate to the isolated location of many of the drilling operations, which range from the swamps of the Orinoco Delta to marine rigs operating 20 miles offshore in Lake Maracaibo.

Incidence and Severity of Fishing Jobs

Statistical information on fishing and recovery operations have been maintained by Creole since 1946. These statistics have included the well name and classification, field or area, date of the fishing job, type of fish involved, method of recovery, and total time spent on the job. The last feature has been defined as the total time spent from the time of occurrence of the fishing job until the fish has been recovered and the hole cleaned out to the original depth, or until the fish has been sidetracked and the sidetrack hole has reached the original depth, or until the fish has been abandoned in place and fishing operations have been terminated. These data have been collated and expressed in terms of incidence of fishing jobs per rig-year and of severity in average days per fishing job.

The incidence and severity of fishing jobs experienced by Creole since 1948 are shown in Table 1.

It will be noted that the incidence of fishing jobs has only varied moderately from the average of 5.7 jobs per rig-year, but that the severity is much more variable, ranging from a low of 1.3 days per job in the first half of 1955 to a high of 7.5 days per job in 1951. The combination of these two factors determines the relative amount of time spent on fishing operations, which ranges from a high of 7.9 per cent of all rig time in 1953 to a low of 2.1 per cent in the first half of 1955. A particularly welcome feature is the marked reduction in the per cent of all rig time spent on fishing during the last 18 months as compared to the average of 6.4 per cent for the years 1948 through 1953. These data are shown graphically in Fig. 1.

Breakdown of Fishing Jobs

All of the fishing jobs that occurred during the period from January 1, 1950, to June 30, 1955, were broken down into five major categories to determine their relative importance with regard to incidence and average severity. A total of 439 fishing jobs occurred during the period, and 1532.1 days were spent on fishing operations. The incidence of fishing jobs was 5.4 per rig-year, and the average severity was 3.5 days per job. The five categories used in the breakdown were stuck pipe, twist-offs, rock bit cones, service company junk, and miscellaneous. The last category received all fishing jobs not applicable to the first four categories.

Stuck Pipe. As might be expected, stuck pipe is the most serious type of fishing job encountered. During the period, 132 stuck pipe jobs occurred, which represents 30.1 per cent of all fishing jobs, and 851.4 days were spent fishing for stuck pipe, which represents 55.7 per cent of all fishing time. Average incidence of stuck pipe fishing jobs was 1.64 per rig-year, and the average severity was 6.45 days per job.

Despite the difficult nature of stuck

TABLE 1. Incidence and severity of fishing jobs since 1948.

Year	1948	1949	1950	1951	1952	1953	1954	First half 1955
Total rig-years operated	32.4	26.3	7.8	13.7	18.8	20.2	13.4	7.4
Total number of fishing jobs during year	231	128	31	47	125	116	75	45
Total number of fishing days during year	856.0	533.2	113.5	349.6	263.8	586.5	141.9	56.8
Incidence, fishing jobs per rig-year	7.1	4.9	4.0	3.4	6.7	5.7	5.6	6.1
Severity, average days per fishing job	3.7	4.2	3.7	7.5	2.3	5.1	1.9	1.3
Per cent all rig time spent on fishing	7.3	5.6	4.0	7.0	4.1	7.9	2.9	2.1

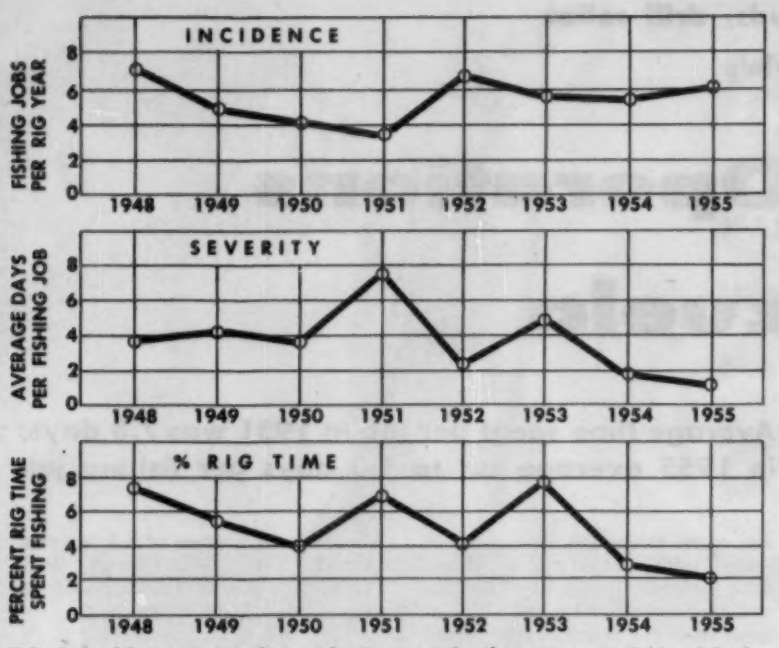

FIG. 1. **Incidence, severity and per cent rig time** spent on fishing jobs by Creole Petroleum Corporation are shown for years 1948—first half 1955.

pipe fishing operations, 104 of the stuck pipe fish were worked free, jarred loose, washed over, or otherwise successfully recovered, which represents 79 per cent of all stuck pipe. The other 28 jobs were unsuccessful and were either sidetracked or the hole was abandoned. The severity of successful jobs was only 1.78 days per job, as compared to a severity of 23.8 days per job for the unsuccessful stuck pipe operations. A measure of the seriousness of Creole's unsuccessful stuck pipe fishing problem is the fact that although they only represent 6.4 per cent of all fishing jobs, they consumed 43.5 per cent of all fishing time during the 5½-year period.

Twist Offs. Twist-offs are the second most prevalent cause of fishing jobs. They are almost always caused by mechanical failure of the drill pipe or drill collars, and are usually recovered with little difficulty, although occasionally the fish becomes stuck and a lengthy wash-over or side-tracking operation results.

Twist-offs caused 121 fishing jobs during the period under review, and a total of 264.3 days were spent on these jobs. Incidence of twist-offs was 1.49 per rig-year, and the average severity was 2.18 days per job. Most of these twist-offs were recovered in one-half a day or less, but a relatively few lengthy jobs requiring side-tracking operations substantially increased the severity of the group as a whole.

A division of the data into drill collar twist-offs and drill pipe twist-offs shows that 80 of the former and 41 of the latter occurred in the period under review. Drill collar twist-offs were thus twice as prevalent as drill pipe twist-offs during the past 5½ years.

"Otis... First in Pressure Control"

An interesting feature of these data relates to the incidence of drill collar twist-offs by years. During the years 1950 through 1952, Creole's major drilling effort was concentrated on shallow Miocene wells, where drill collar service was not particularly severe. Because of the steel shortage, Creole went through most of this period with only minor replacements to its drill collar supplies. In 1953, however, the emphasis shifted to the deeper Eocene drilling in Lake Maracaibo, and the relatively old drill collars then in use started to twist off with increasing frequency and several lengthy fishing jobs resulted.

A study made in early 1953 showed that the collars then in use ranged up to 5 years in age, and, as a result, a broad replacement program was put into effect with the first substantial shipment of new collars arriving in mid-1953. Almost immediate results were obtained, and the incidence of drill collar twist-offs dropped to nearly zero in 1954. These results are shown graphically in Fig. 2 and 3.

Lost Rock Bit Cones. Another common classification of fishing job is lost rock bit cones. Fifty-one such fishing jobs occurred during the period, for an average incidence of 0.63 jobs per rig-year. A total of 56.1 days were spent in fishing for the cones or in drilling them up, for an average severity of 1.1 days per job. Lost rig time from rock bit cones left in the hole generally ranges from 0.5 to 2.0 days per incident, and only one job of as much as 10 days was experienced during the five-and-a-half-year period.

Service Company Tools. This classification of fish relates only to service company tools run on cables or wire line, and consists of various well logging plummets, dipmeters, calipers, wire-line coring guns and bullet, and shaped charge perforating devices. Fifty such fishing jobs occurred during the period for an average incidence of 0.62 jobs per rig-year, and 86.20 days were spent in fishing for service company tools for an average severity of 1.72 days per job. Most of these jobs are of short duration, but occasional lengthy fishing jobs ensue when large amounts of wire line or cable become jammed in the casing.

Of some concern to Creole is the generally rising incidence of fishing jobs relating to service company tools during the last several years. Reason for the rising incidence is due at least in part to the increasingly frequent use of the many logging devices and other specialized services, particularly in exploratory wells. This rising trend is shown graphically in Fig. 4.

Miscellaneous Fishing Jobs. This is a catch-all category for all fishng jobs not falling into the previously discussed categories. It consists in large part of minor fishing jobs due to dropping or loosing hand tools, slips, and other small objects in the well bore, but also includes sanded up or stuck packers and other tools used in the completion and testing of the wells. Most serious type of job falling in this category is the occasional case where tubing or drill pipe is cemented in the well during squeeze-cementing or plug-back operations. When this type of job occurs, it generally results in junking the well or in extensive milling and side-tracking operations.

Eighty-two miscellaneous fishing jobs occurred during the period for an average incidence of 1.01 jobs per rig-year, and 271.7 days were expended on these fishing operations for an average severity of 3.31 days per job. No significant trend is apparent in the year by year incidence or severity of this category of fishing job.

Breakdown by Areas

As might be expected, the incidence and severity of fishing jobs varies widely in different areas. Some fields experience relatively little fishing, while others have an extremely serious problem.

A breakdown of the fishing data by

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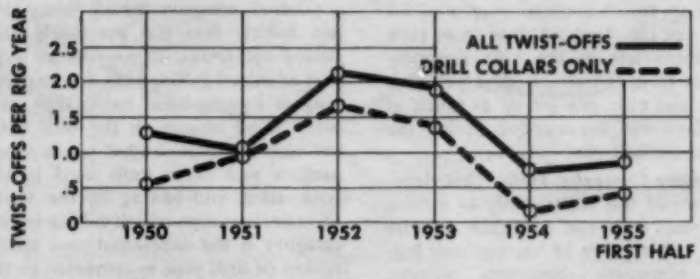

FIG. 2. **Twist-offs per rig-year.** Dotted line shows comparison of twist-offs due to drill collars with all twist-offs.

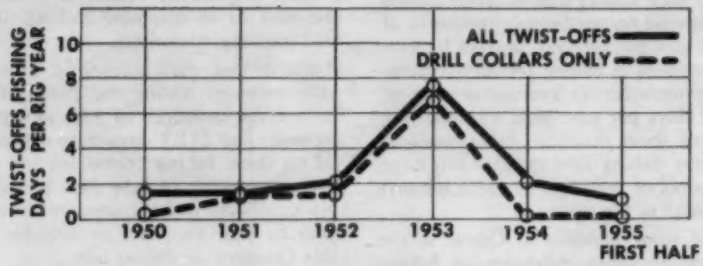

FIG. 3. **Fishing time for twist-offs** per rig-year indicates that in the years 1954 and first half 1955 time spent was reduced considerably.

major fields and well classifications for the period from January 1, 1950, to June 30, 1955, shows the wide variation that is experienced in fishing operations. These data are shown in Table 2.

TABLE 2. Fishing data breakdown by areas and well classification.

Area or classification	Rig-years operated	Incidence, jobs/rig-year	Severity, days/job	Per cent all rig time spent fishing
Quiriquire, field wells and outposts	7.00	5.4	1.0	1.4
Pedernales, field wells and outposts	3.06	7.2	8.0	15.8
B.C.F. Miocene, field wells and outposts	12.62	3.4	3.2	2.9
B.C.F. Eocene, field wells and outposts	19.52	4.8	3.1	4.0
All other fields, field wells and outposts	11.00	3.8	2.3	2.4
All wildcats and deeper pool tests	27.66	7.1	4.1	7.8
All Creole-operated wells	81.19	5.4	3.5	5.2

It will be noted that the incidence of fishing jobs varies from a low of 3.4 per rig-year in the Bolivar Coastal field Miocene wells to a high of 7.2 jobs per year in Pedernales field. The average severity varies even more markedly with a low of 1.0 day per job in the Quiriquire field to a high of 8.0 days per job in the Pedernales field. The per cent of all rig time spent on fishing operations is a function of the product of these two factors, and as a consequence, the percentage rises rapidly when both the incidence and severity are relatively high. This is illustrated graphically in Fig. 5.

Quiriquire Field. The Quiriquire field in eastern Venezuela has been on production for about 25 years, and a one-to-two rig program on development and outpost drilling has been in progress in recent years. The productive formations are relatively shallow ranging from 3500 ft to 5000 ft in depth, and the strata penetrated consist of continental to shallow marine clays and boulder beds.

These formations are very competent and do not tend to slough or cave while drilling, and, as a consequenece, stuck pipe is almost unknown in the field. The hard boulder beds, however, require considerable weight on the bit and twist-offs are quite frequent, but the fish are usually recovered with the first run of an overshot.

Quiriquire is thus characterized by a moderately high incidence of 5.4 fishing jobs per rig-year, but it has the lowest severity of any area with an average of only one day per job. As a result of this low severity, Quiriquire has had less fishing than any other field or area with only 1.4 per cent of rig time lost to fishing operations.

Pedernales Field. The Pedernales field is located in an isolated area in the delta of the Orinoco River. It was discovered in 1935, and a sporadic one-rig program on development and outpost drilling has been carried on in recent years.

Average well depth is about 7000 ft, and the formations penetrated consist of soft, water-sensitive shales and unconsolidated sands. Further complications result from the fact that formation pressures are abnormal and dips average 45 per cent. The soft shales slough badly when exposed to the filtrate from drilling muds, and stuck pipe is a continuous problem in the area.

Both the incidence of 7.2 fishing jobs per rig-year and the average severity of 8.0 days per job are record highs for Creole's operations, and the combination of these factors results in 15.8 per cent of all rig time spent on fishing operations. This is almost exactly twice as high a percentage as is experienced in Creole's wildcat drilling operations.

Use of very low water-loss emulsion drilling muds on some of the most recent wells drilled in Pedernales has resulted in a substantial reduction in both the incidence and severity of fishing operations, as compared to earlier wells drilled in the area.

Bolivar Coastal Field — Miocene Wells. Creole's portion of the Bolivar field underlies the water of Lake Maracaibo, and it is Creole's most important producing area. An average of two to three rigs have been used on development and extension drilling in the BCF-Miocene in recent years. The Miocene oil sands range from 3500 ft to 5000 ft in depth and the strata drilled consist of soft marine shales and unconsolidated sands. Drilling rates are very high ranging up to 300 ft per hour, and in many cases water can be used for drilling fluid down to the top of the producing sands.

Both the incidence and severity of fishing jobs are relatively low, and only

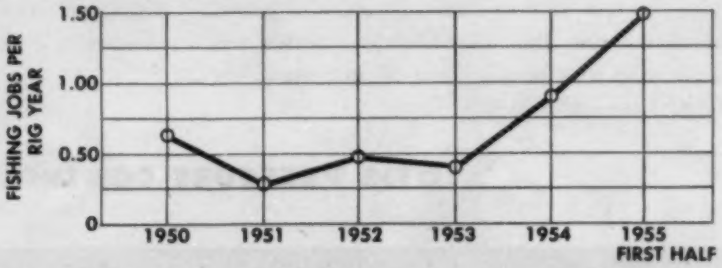

FIG. 4. **Fishing jobs for service tools** per rig-year show an increase due to the many types of service tools run in recent years compared to early years.

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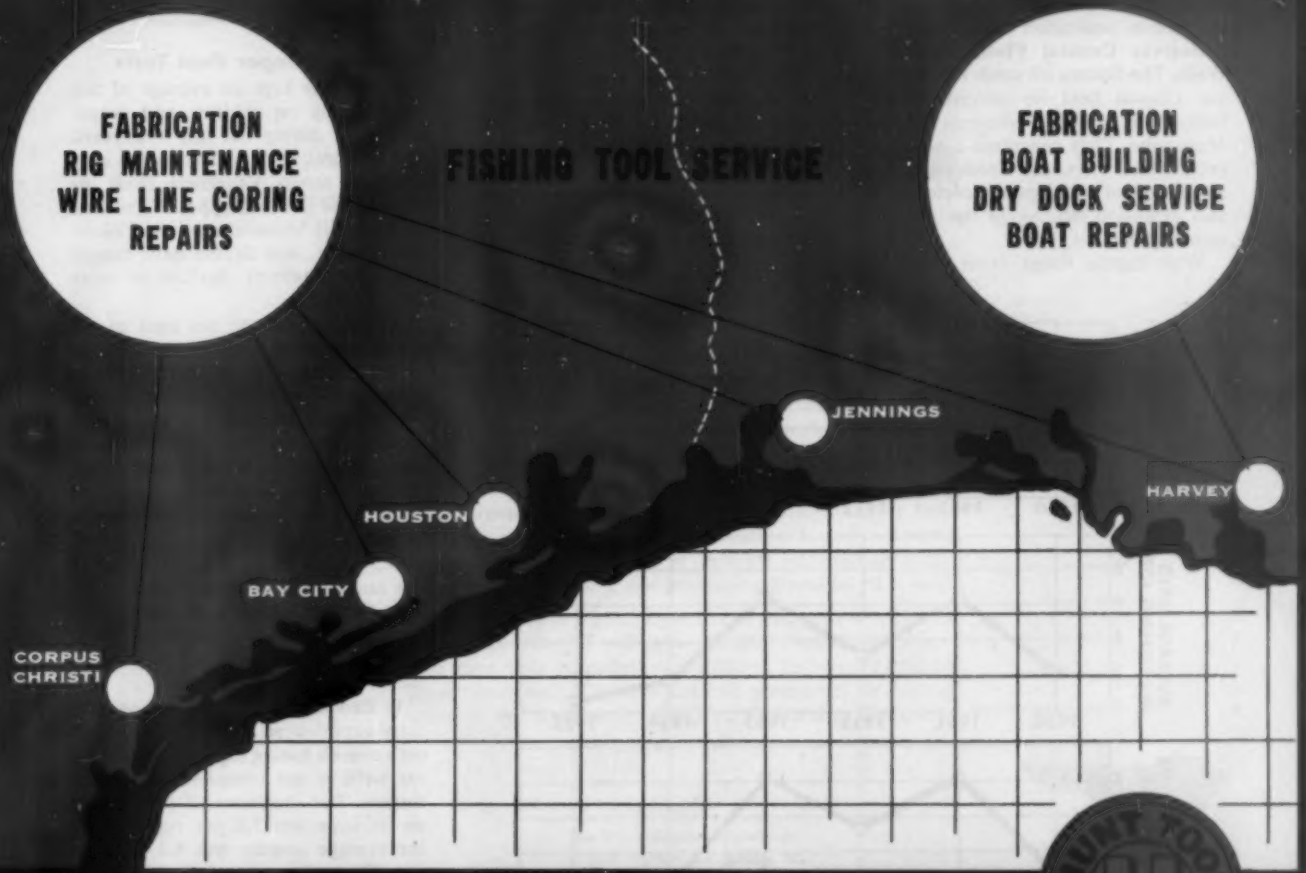

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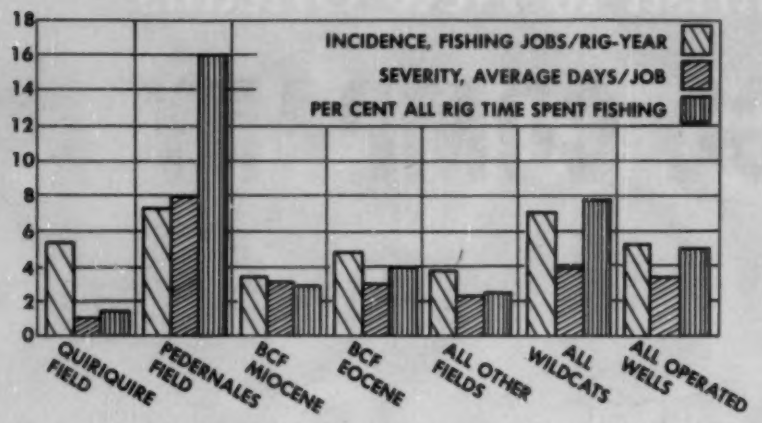


FIG. 5. **Fishing data by areas** and well classification show by comparison that drilling problems are more difficult in the Pedernales field.

2.9 per cent of rig time is expended on fishing operations. It is possible that the severity of fishing operations should be further reduced on Miocene wells by use of a good quality drilling mud; however, this could only be accomplished by a drastic and uneconomic sacrifice in peneration rates.

Bolivar Coastal Field — Eocene Wells. The Eocene oil sands in the Bolivar Coastal field lie unconformably beneath the Miocene sediments in Lake Maracaibo. They constitute a group of prolific reservoirs, and Creole has kept an average of four rigs on development and extension drilling in the area in recent years.

Well depths range from 5000 to 7000 ft, of which the lowermost 500 to 2500 ft is the harder Eocene formation. The overlying Miocene sediments are the same as in the Miocene producing areas described above, but the Eocene consists of medium-hard to hard marine shales and sands and penetration rates are in the range of 3 to 10 ft per hour.

Twist-offs, which are very rare in the Miocene sediments, occur quite frequently in the harder Eocene, and, as a consequence, the incidence of fishing jobs is about 40 per cent greater on Eocene wells than on Miocene completions. Severity of fishing jobs is about the same in both classes of wells with an average of a little more than three days per job, and 4.0 per cent of all Eocene rig time was spent on fishing operations.

All Other Fields. All fields wells and outposts not falling in the previously mentioned fields were combined in this category. The fields involved were Jusepín, Pilón and San Joaquín in eastern Venezuela, and Mara and Cumarebo in western Venezuela. All of these fields have had some development activity during the last 5½ years; however, no individual field averaged as much as one rig in operation for the whole period.

Well depths range from 3500 ft in the Cumarebo field to a maximum of 10,500 ft in the Mara field. None of these fields have serious fishing problems, and the group as a whole did better than any of the previously mentioned fields with the exception of Quiriquire. Incidence of fishing jobs was somewhat lower than average at 3.8 jobs per rig-year, and the severity was substantially below average at 2.3 days per job. Only 2.4 per cent of all rig time was spent on fishing operations in these fields.

Wildcats, Deeper Pool Tests

Creole has kept an average of five rigs running on wildcats and deeper pool tests during the last 5½ years. The exploration effort has been widely scattered across Venezuela from the delta of the Orinoco opposite Trinidad to the Perijá Mountains on the Colombian border, and depths have ranged from the relatively shallow to more than 17,000 ft.

Approximately 20 per cent of the exploratory drilling effort was centered in the general area of the Pedernales field, where extremely severe drilling problems are encountered. The area is characterized by mud flows, heaving shale, high-pressure salt water flows, and formation pressures, which are practically identical with overburden pressures.

Out of 12 deep wildcats drilled in this area by all operators since 1946, only 6 have managed to reach their projected total depth, and two of these were unable to run logs or casing in the lower part of the hole.

In view of the extreme drilling difficulty experienced in some areas, Creole's overall fishing experience on wildcat wells is not considered to be excessive. The incidence of fishing jobs on wildcats was 7.1 per rig-year and the average severity was 4.1 days per job. The proportion of all wildcat rig time spent on fishing operations was 7.8 per cent.

When plotted on a yearly basis, the incidence of fishing jobs on wildcats is relatively uniform; however, the

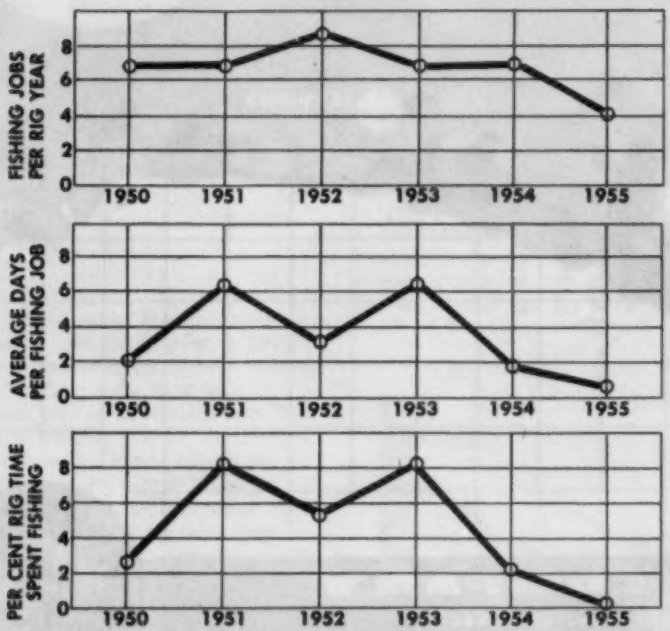
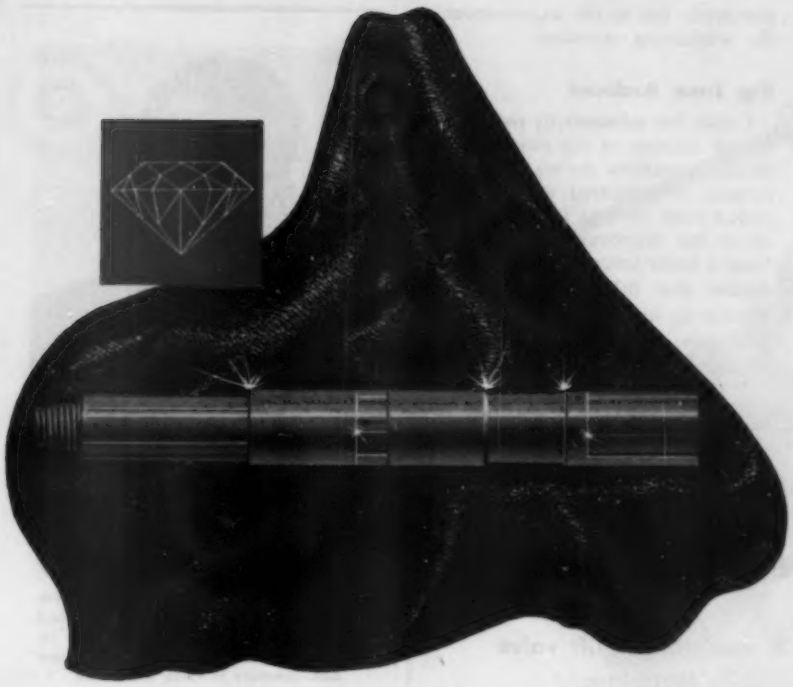


FIG. 6. **Fishing data on wildcat wells** by years indicate the downward trend in number of jobs, average time and per cent of rig time spent on fishing.



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severity has varied widely and has been the principal controlling factor in the amount of time spent on fishing operations. This is illustrated in Fig. 6. Similarity between the severity curve and the curve of per cent rig time spent on fishing is readily apparent.

A comparison of Fig. 6 with Fig. 1 shows the marked influence of wildcat fishing jobs on the overall fishing statistics. It particularly indicates that the poor fishing records experienced in 1951 and 1953 were largely a result of wildcat fishing problems, and also that the marked drop in overall fishing during the last 18 months is principally due to the improvement in the wildcatting statistics.

Rig Time Reduced

Creole has substantially reduced the overall amount of rig time spent on fishing operations during the last 18 months as compared to that in the period from 1948 to 1953. Practically all of this improvement has resulted from a lower severity ratio, which indicates that fishing jobs are being cleaned up in less time than in previous years.

Several factors have contributed to this improvement, of which the three most important are:

(1) *Creole's Drilling Training Program.*

For the past 2 years, Creole has been carrying on an intensive training program for rig floor supervisors covering all phases of drilling operations. This program has paid off in a big way, particularly through increasing job knowledge of the Venezuelan drilling supervisors.

(2) *Increased Use of Oil-Emulsion Muds.*

Creole has made increasingly wide use of oil-emulsion muds for deeper drilling in areas where fishing has been a major problem. The better lubricating properties of these muds greatly facilitate the recovery of stuck pipe and twist-offs.

(3) *Drill Collar Replacement Program.*

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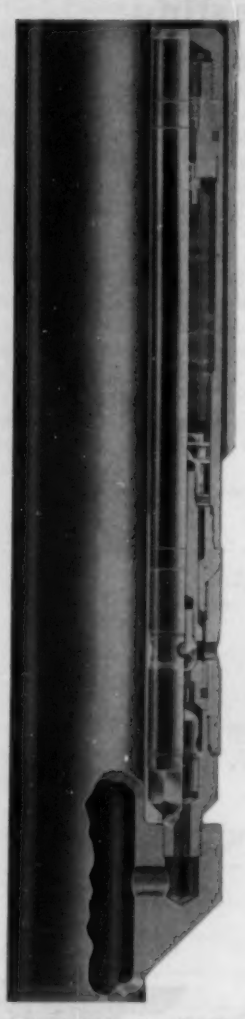
The Author

Robert W. Beck has been an employee for the last 10 years of the Creole Petroleum Corporation, a Venezuelan affiliate of the Standard Oil Company (New Jersey). At present he is drilling engineer in the Caracas Office.

Beck was graduated from North Dakota State College in 1938 and worked for six years in production research department of Stanolind Oil and Gas Company in Tulsa, Oklahoma.



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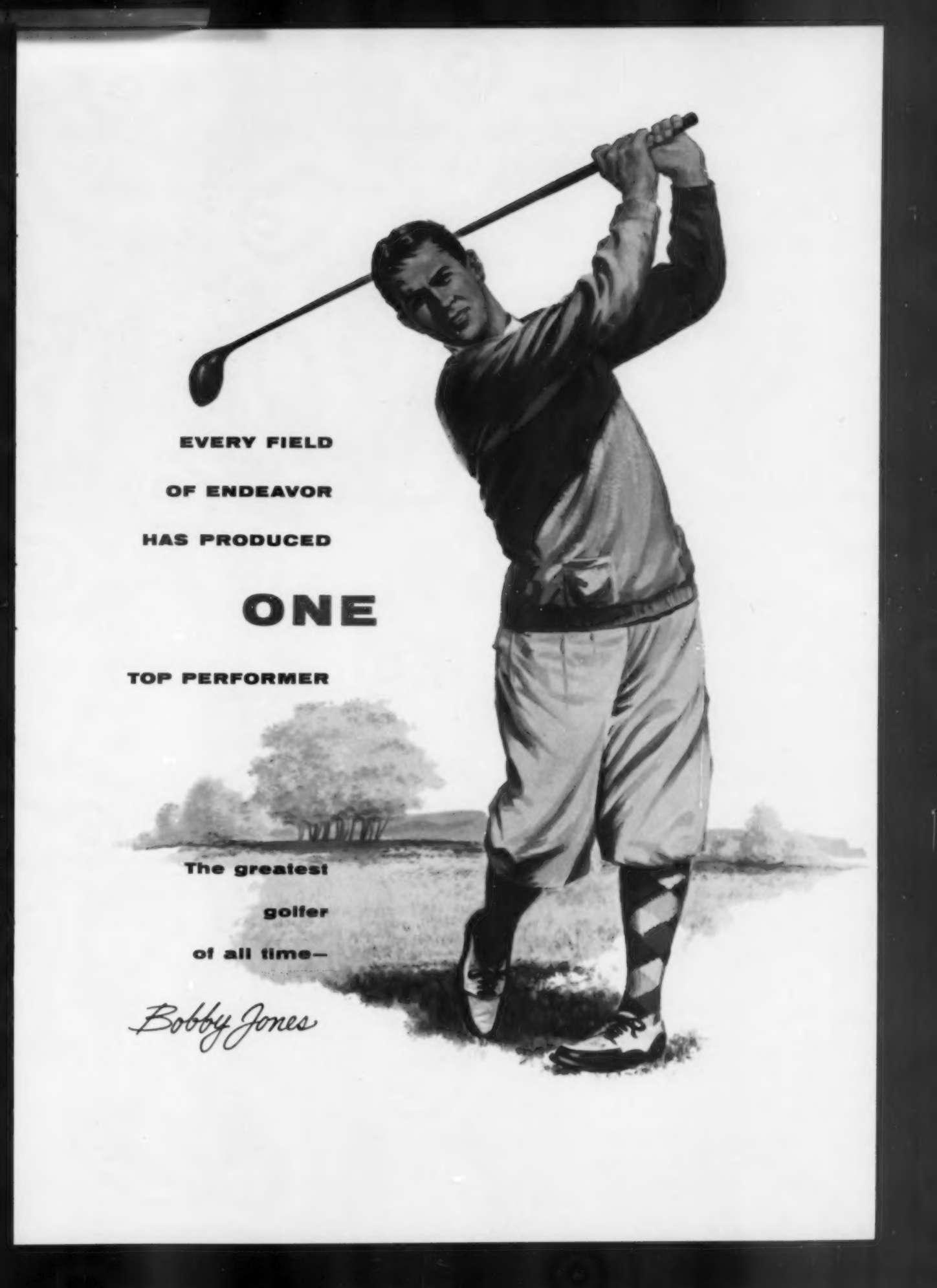
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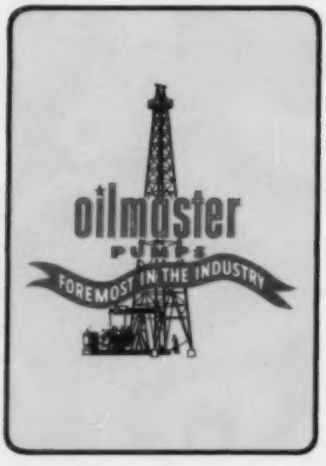

Predicting Water Flood Behavior

In a Formation Having Permeability Stratification

Predictions based on experimental results obtained by use of a fluid mapper model.

William C. Hauber and D. E. Menzie

To determine whether it will be economically feasible to water flood a specific formation, it is necessary to predict the amount of additional oil recovery resulting from such a flood. This prediction is based primarily on an estimate of the additional amount of oil which will be recovered from a specific unit of sand and an estimate of the volume of the formation which will be swept out by the injected water. The product of these estimates is equal to the additional recovery resulting from the flood.

The amount of additional oil which will be recovered from a specific unit of sand can be indicated by conducting laboratory experiments on a sample of the sand. The value of the data obtained from such experiments is questionable because it is impossible to obtain a representative sample of the whole reservoir. Even if the sample is representative, another important difficulty arises in the application of the results of these experiments to practice in the field. Differences in behavior are to be expected between reservoirs of the dimensions encountered underground and those used in laboratory work. At the present time, however, this is the only practical method of obtaining this information.

The first step in calculating the volume of the formation that will be swept out by the injected water is computing the volume of the formation from geological information. If the permeability of the formation is substantially uniform, the volume of the formation swept out may then be obtained by multiplying the volume of the formation by a "sweep-out efficiency." Sweep-out efficiency is the percentage of the total formation that is behind the flood front. There are numerous articles in the literature of petroleum engineering which give values of the sweep-out efficiency at breakthrough of the injected water to the producing wells for various conditions occurring in the formation.

If the permeability of the formation is not uniform, water will break through to the producing wells first in the zones of the formation having high horizontal permeability. In the zones having low horizontal permeability, the water may not break through before the economic limit is reached. In order to determine the volume of the formation swept out at any time, the permeability stratification technique has been developed. In this technique the formation is replaced by parallel layers. The volume swept out is approximated by superposing the independent fluid movements in the individual layers.

Several analytical methods have been presented for determining the amount of fluid movement in each layer. Yuster, et al,[23,24] Suder,[22] and Stiles[21] presented methods based on the assumptions that the water penetration in each layer was directly proportional to the horizontal permeability of the layer and that the oil cut, the oil production rate as a fraction of the total production rate, was proportional to the capacity distribution of the formation. Dykstra and Parsons,[4] Muskat,[19] and Calhoun[1] presented methods that also take into consideration the differences in mobility between the oil and water.

These methods are based on the premise that the residual oil saturations behind the flood front and the oil saturations in the uninvaded sections of the reservoir are constant throughout the reservoir. Aside from this premise, these methods are based on three fundamental assumptions: (a) vanishing cross-flow between layers, (b) no increase in area swept by the flood after breakthrough of the injected water to the producing well, and (c) the absence of stripping action behind the flood front. Muskat[19] claims that these assumptions should give the least favorable expectations for the performance of a water flood.

It has been shown by several investigators [5, 11, 3] that the assumption of no increase in area swept by the flood after break-through tends to produce an error in calculating oil recovery. A fluid mapper model was used in this investigation to determine the order of magnitude of this error and to present a method of eliminating this error in predicting water flood behavior.

The fluid mapper model was originally developed by Hele-Shaw[6,7,8,9,10] in 1897. In 1945 Moore[13,14,15,16,17] published a series of articles describing the construction of an inexpensive model for the study of field potential problems. Rose and Gilchrist[20] and Cheek[2] applied Moore's techniques to petroleum engineering problems. The construction and operation of a model to simulate a water flood has been adequately described by Cheek[2] and the detailed process will not be repeated here.

The fluid mapper model consists of a slab of dental stone resembling a water flooding pattern. Spacers, approximately 40 mils thick, are placed on top of the slab and a piece of plate glass is laid on the spacers forming a flow channel. The boundaries of the flooding pattern are sealed by barriers in the flow channel and the model is placed in a tray of water as shown in Fig. 1. The displacing fluid, colored water, is injected into the flow channel and clear fluid is displaced from the flow channel simulating a water flood.

The application of the fluid mapper model in predicting water flood behavior is based on the analogy between Darcy's law and the formula for the

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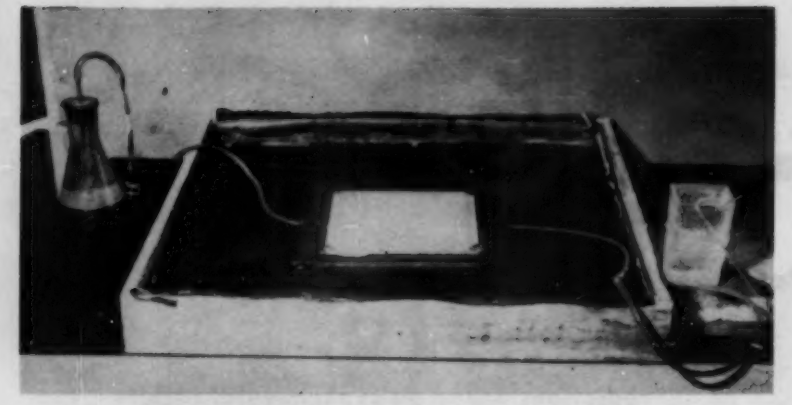

FIG. 1. Flooding pattern boundaries are sealed by barriers in flow channel and model is placed in a tray of water.

fluid carrying capacity of a narrow linear channel as given by Lamb.[12] According to this analogy, the permeability of the formation is analogous to the square of the thickness of the flow channel in the model.

Fluid mapper models simulating a five-spot water flooding pattern were constructed for this investigation. Table 1 shows the values of areal sweep-out efficiency at breakthrough obtained

TABLE 1. Areal sweep-out efficiency five-spot flooding pattern.

Run No.	Model Type	Size flow space in.	Thickness flow space mils	Injection rate cc/sec.	Sweep-out Efficiency %
1	element	16½ x 16½	42	0.280	73.0
2	element	16½ x 16½	42	0.226	73.2
3	quadrant	8¼ x 8¼	42	0.0508	73.3
4	quadrant	8¼ x 8¼	42	0.0512	70.3
5	quadrant	8¼ x 8¼	23	0.00907	73.2
6	quadrant	8¼ x 8¼	23	0.0313	72.9

with these models by using a mobility ratio of unity. The average sweep-out efficiency was 72.6 per cent. It is interesting to note that the sweep-out efficiencies obtained by using different values of the thickness of the flow channel and different injection rates are in close agreement. This appears to indicate that the areal sweep-out efficiency of a uniform permeability layer in a flooding pattern is independent of the absolute permeability of the formation and the rate of water injection.

The behavior of a five-spot pattern after breakthrough is illustrated in Figs. 2 and 3. These figures show how the area swept out by the invading fluid continually increases after breakthrough until the total area of the five-spot pattern is swept out. Fig. 2 illustrates an element of a five-spot pattern with the fluid being injected into the four corner wells and being produced from the center well. Fig. 3 illustrates a quadrant of a five-spot pattern. In these figures, the numbers represent the percentage of the total flow space area that has been swept out by the invading fluid. As these figures show, the assumption that at water breakthrough a formation goes completely to water production is definitely erroneous.

Runs under different conditions of permeability and injection rates were made to obtain a general performance curve for a five-spot water flood with a mobility ratio of unity between the displaced and injected fluids. This curve was obtained by plotting the per cent of the model area swept out versus the volume of fluid injected for each run. The oil* production rates were obtained by taking the slope of these curves. These rates were represented on a relative scale *by* dividing the oil production rate by the total production rate. In Fig. 4 these rates are plotted against relative volume of injected water values. There values were obtained *by* dividing the volume of water injected by the volume which was injected at the time of breakthrough of the injected water to the producing well. Since the runs which were used to make this curve were made at different rates of injection and with different absolute permeabilities of the model, the general performance curve for a water flooding pattern appears to be independent of the permeability of the system or the rate of water injec-

*Oil is the term used to represent the displaced fluid in the fluid mapper model used in this investigation.

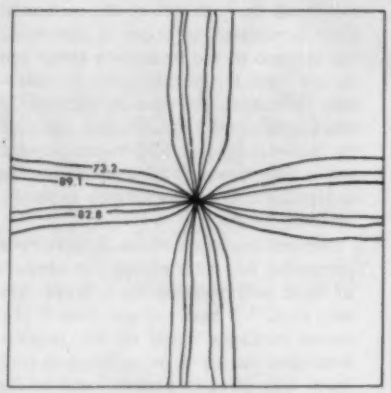

FIG. 2. Increase in area swept out by invading fluid after break-through for an element of a five-spot flooding pattern.

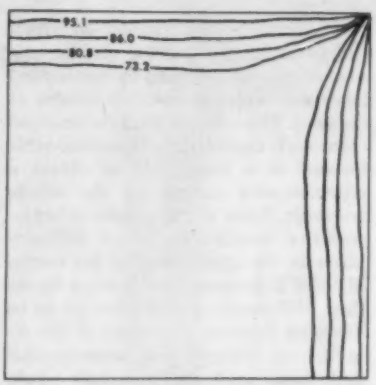

FIG. 3. Increase in area swept out by invading fluid after break-through for a quadrant of a five-spot flooding pattern.

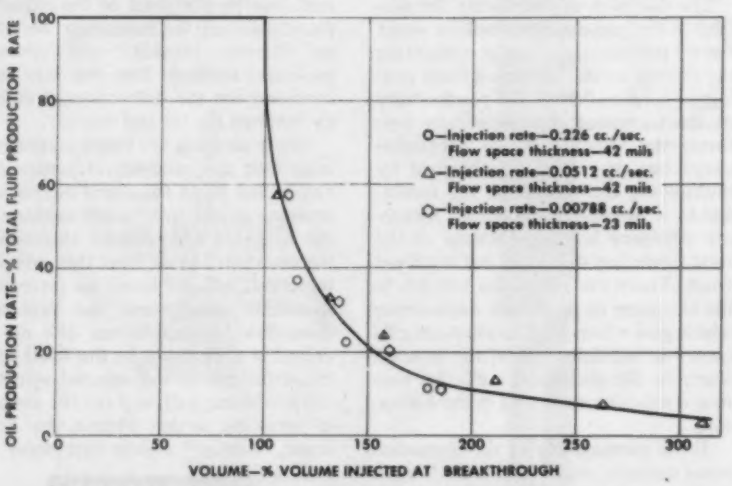

FIG. 4. General performance curve for a five-spot flooding pattern.

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tion into the system. Since the sweep-out efficiency at breakthrough has been found to be dependent upon the mobility ratio between the displaced and injected fluids, the performance curve for any given flooding pattern should also be a function of the mobility ratio.

By the use of a performance curve it is possible to predict the history of any five-spot water flood in a formation of uniform permeability. This curve may be directly applied to a constant rate of water injection system by setting the time required for the injected fluid to break through to the producing well as one hundred per cent on the volume scale. To apply a performance curve to a constant pressure injection system, it is necessary to obtain a curve showing the total fluid production rate as a function of time. This curve can be obtained from a fluid production rate as a function of time curve for a fluid mapper model with a constant pressure differential maintained across the model. The area under this curve would be equal to the volume of fluid injected into the system. Since the initial injection rate and the volume of fluid injected at breakthrough can be calculated,[1] the time of breakthrough can be determined for the formation. Applying the initial injection rate and the time of breakthrough to the above curve, the fluid production rate as a function of time curve is obtained. Measuring the area under the fluid production rate as a function of time curve will give the volume injected as a function of time. With this information, the oil production rate as a function of time curve can be calculated.

To evaluate the effect of oil recovery after breakthrough on a water flood prediction for a formation having permeability stratification, a hypothetical permeability distribution curve, Fig. 5, was chosen. This curve is for a formation 38 ft thick having a maximum permeability of 100 mds and a minimum permeability of 0.5 mds.

The permeability distribution curve was broken into five brackets so that the performance curve could be applied to each bracket. These brackets are shown as dotted lines on the permeability distribution curve, Fig. 5, and are tabulated in Table 2. The capacity of each bracket was obtained by multiplying the average permeability of each bracket in millidarcies by its thickness in feet. As shown in Table 2, the total capacity of the formation is 696.1 mds feet. To obtain the average permeability of the formation, the total capacity of the formation was divided by the total thickness. This gave an average permeability of 18.3 mds for this hypothetical sand.

TABLE 2. Permeability and capacity of brackets used for water flood prediction.

Bracket No.	Average permeability mds.	Thickness ft	Capacity mds ft
1	1.3	14	18.2
2	7.1	10	71.0
3	23.2	7	162.4
4	50.0	4	200.0
5	81.5	3	244.5
		38	696.1

The following physical properties were assumed for the hypothetical formation:

Spacing — 10 acres

Area — A — 435,600 sq ft

Porosity — ϕ — 20 per cent

Initial oil saturation — S_{oi} — 70 per cent

Initial water saturation — S_{wi} — 30 per cent

Mobility ratio — 1

Residual oil saturation — S_{or} — 23 per cent

Formation volume factor — B — 1

The volume of recoverable oil in the formation is given by:

$$V = A\,h\,\phi\,(S_{oi} - S_{or})$$
$$V = 435{,}600 \times 38 \times 0.2 \times (.70 - .23)$$
$$V = 1{,}557{,}000 \text{ cu ft} \quad . \quad . \quad (1)$$

If the areal sweep-out efficiency, S, is assumed to be 72.6 per cent, it is possible to calculate the water injection rate at which water would break through to the producing well in ten years time, T, if the formation had uniform permeability. This rate is given by the following formula:

$$Q = \frac{VS}{T} = \frac{1{,}557{,}000 \times .726}{5.61 \times 3650} =$$
$$55.2 \text{ bbl per day} \quad . \quad . \quad (2)$$

5.61 was inserted into the formula to

TABLE 3. Determination of the time of breakthrough and the rate of injection for each permeability bracket.

Bracket No.	Av. permeability md	Time breakthrough years	Injection rate bbl/day/ft	Thickness ft	Injection rate bbl/day
1	1.3	140.70	0.103	14	1.44
2	7.1	25.80	0.504	10	5.04
3	23.2	7.88	1.842	7	12.90
4	50.0	3.66	3.970	4	15.88
5	81.5	2.33	6.470	3	19.38
					55.24

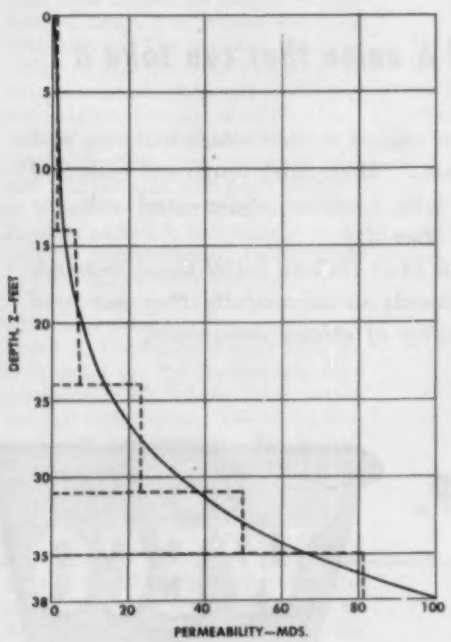

FIG. 5. Hypothetical permeability distribution curve.

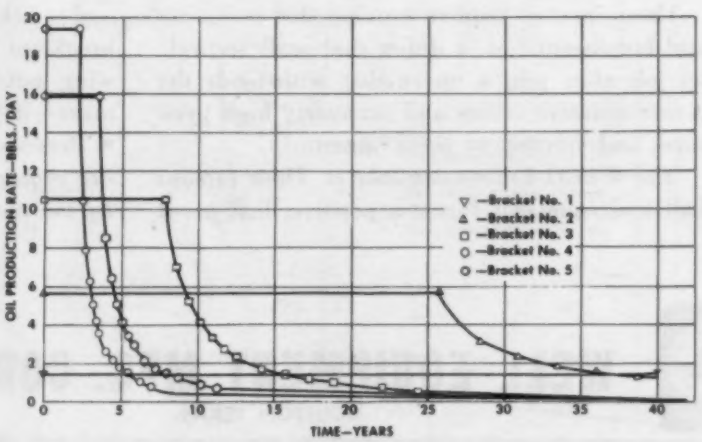

FIG. 6. Oil production rates in permeability brackets of hypothetical formation.

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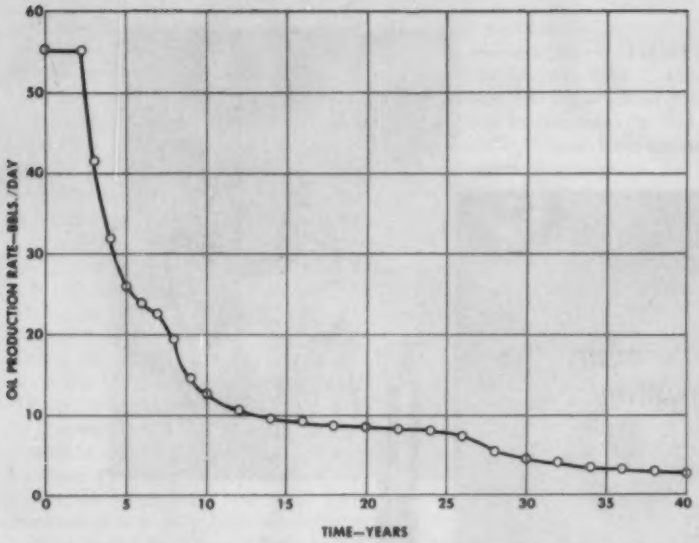


FIG. 7. Composite oil production rate curve for the hypothetical formation.

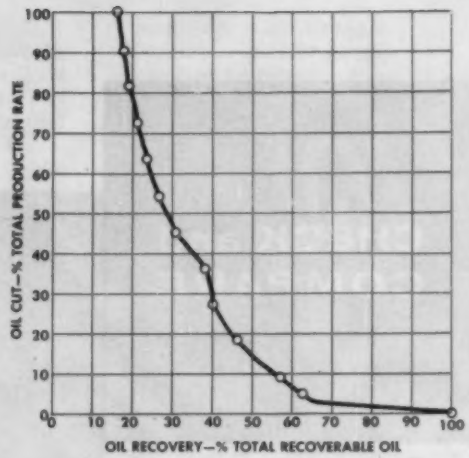
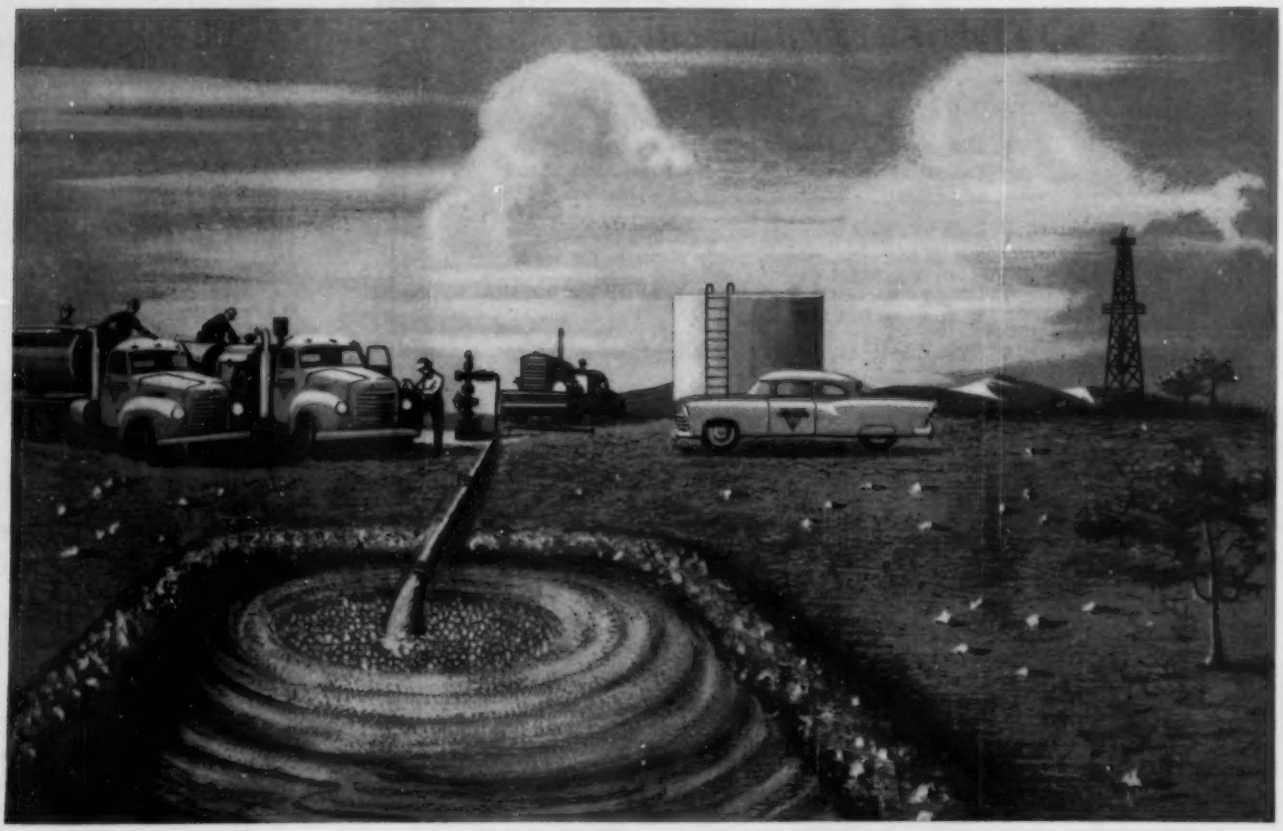


FIG. 8. Oil cut vs oil recovery curve for hypothetical formation.

convert cubic feet into barrels. To obtain the rate of water injection per foot of thickness, the total rate of injection, 55.2 bbl per day, was divided by the thickness, 38 feet, which gave a rate of 1.45 bbl per day per ft. Table 3 was constructed to determine the time of breakthrough of each permeability bracket and the rate of water injection into each permeability bracket. The time of breakthrough in years was obtained by multiplying 10 years by the average permeability of the formation and dividing by the average permeability of the bracket. The injection rate in barrels per day per foot was obtained by multiplying 1.45 barrels per day per foot by the average permeability of the bracket and dividing by the average permeability of the formation. The total rate of injection into each bracket was obtained by multiplying the rate in barrels per day per foot by the thickness of the bracket.

The oil and water production rate versus time curves for each bracket may be obtained by applying their re-



spective breakthrough times and injection rates to the general performance curve, Fig. 4. Since a constant rate of water injection system and a mobility ratio of unity have been assumed, the volume scale of the performance curve is equal to the time scale. Fig. 6 is the graphical representation of the oil production rates for each bracket. It was necessary to extrapolate the curves for brackets 3, 4 and 5 to 40 years to reach the assumed economic limit, a water-oil ratio of 20:1. The composite oil production rate for the formation was determined by summing the oil production rates in each bracket at corresponding times. Fig. 7 is a graphical illustration of the oil production rate versus time curve for the formation. The humps in this graph at 7 and 27 years are due to the water breakthrough in brackets 3 and 4 respectively.

An oil cut curve showing the oil production rate versus oil recovery was obtained from the oil production rate history. The oil production rate was taken directly from Fig. 7 by dividing the oil production rate at a given time by the total fluid production rate. The oil recovery was obtained by taking the area under the oil production rate versus time curve to a given time and dividing by the total recoverable oil in the formation. The total recoverable oil was given by equation 1 to be 1,557,000 cu ft or 277,500 bbl. Fig. 8 is the graphical representation of the oil cut versus recovery curve. There is a slight hump at an oil recovery of 39 per cent in this curve. This hump was caused by the hump in Fig. 7 at 7 years. This hump could be eliminated by dividing the permeability distribution curve, Fig. 5, into more brackets. However, since the division of the permeability distribution curve into more brackets greatly increases the amount of computations necessary to arrive at an oil cut curve, Fig. 8 is sufficiently smooth for practical purposes.

To illustrate the effect of neglecting the increase in the area swept out after breakthrough, an oil cut curve was derived for this hypothetical formation by the use of Stiles' method[21]. Since unity mobility ratio was used in this investigation, Stiles' method should give as accurate a prediction of the oil cut curve as the other analytical methods[4,19,1] which take mobility ratio into consideration and are more tedious to apply. Inasmuch as the technique of applying Stiles' method is adequately described in the literature, it will not be presented here. Fig. 9 is the oil cut curve obtained by applying Stiles' method to the hypothetical formation.

Since Stiles' method is based on a

The Authors

W. C. Hauber

D. E. Menzie

William C. Hauber is a petroleum supply officer with the United States Air Force in France. He is on a military leave of absence from Shell Oil Company where he was a junior exploitation engineer. He received his BS degree in mechanical engineering from Kansas State College in 1953. He has completed his requirements for his masters degree in petroleum engineering at the University of Oklahoma.

D. E. Menzie has been an associate professor of petroleum engineering at the University of Oklahoma for four years. Prior to this time he taught at The Pennsylvania State University for two years and was employed for three years as a research assistant on a Pennsylvania Grade Crude Oil Association research project on secondary recovery of oil. He holds BS and MS degrees in petroleum engineering from The Pennsylvania State University and is doing additional advanced work at that institution on a leave of absence to August 31, 1956.

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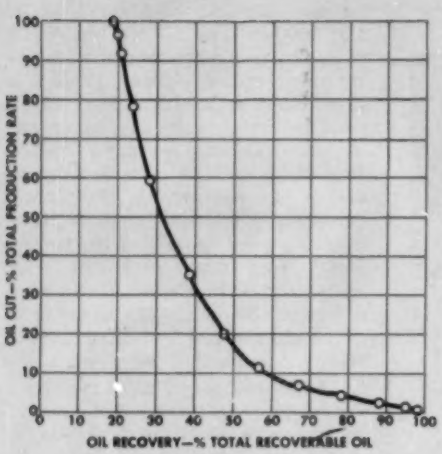

FIG. 9. Oil cut vs oil recovery curve for Stiles' method.

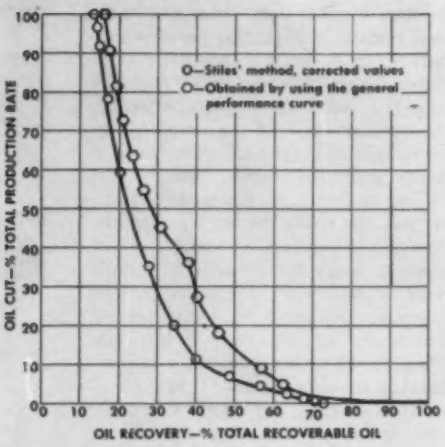
O—Stiles' method, corrected values
O—Obtained by using the general performance curve
OIL CUT—% TOTAL PRODUCTION RATE
OIL RECOVERY—% TOTAL RECOVERABLE OIL

FIG. 10. Effect of assumption that each permeability stratum changes to water production at breakthrough on oil cut vs oil recovery curve.

linear system, it is necessary to multiply the predicted values of oil recovery by a sweep-out efficiency in order to apply the method to a pattern flood. In Fig. 10 the oil cut is plotted against corrected oil recovery values obtained by multiplying the recovery values in Fig. 9 by an assumed sweep-out efficiency of 72.6 per cent. The oil cut curve obtained by the use of the general performance curve was also plotted in Fig. 10. The oil recovery for a given oil cut, as predicted by Stiles' method, is less than the oil recovery for the same oil cut obtained by using the general performance curve since Stiles' method neglects the oil recovery after breakthrough. If the economic limit is assumed to be a water-oil ratio of 19:1, or an oil cut of 5 per cent, the oil recovery, as predicted by using the general performance curve, is 62.4 per cent. This introduces a correction of 13 per cent in predicting the oil recovery obtainable from this hypothetical field by the use of Stiles' method.

Summary

In predicting the water flood behavior of an oil field, the analytical approach may be used by increasing the sweep-out efficiency at breakthrough for the water flooding pattern by the accepted figure of 10 to 15 per cent. However this method is unreliable since the required amount of increase in sweep-out efficiency will depend upon the permeability distribution of the formation and the mobility ratio between the displaced and injected fluids. To overcome this difficulty, it is recommended that a fluid mapper model be constructed to simulate the pattern existing in the field and that a general performance curve be obtained for this pattern by using the same mobility ratio between the displaced and injected fluids as exists in the field. Superposition of the production rate versus time curves for each bracket will, as previously described, give the oil production rate history of the formation.

This technique can be applied to both constant pressure and constant rate injection systems. The application to a constant pressure system consists of calculating the oil production rate versus time curves for each bracket by considering each bracket a separate formation. The application to a constant rate system when the mobility ratio is other than unity is hampered by the difficulty that the total fluid production rate from each bracket is going to change with time. This change is caused by the change in fluid conductivity as the flood progresses through the bracket. To circumvent this difficulty, it is necessary to calculate an oil cut recovery curve for an assumed constant pressure system. This curve will also be applicable to a constant rate system since these systems are fundamentally the same. The oil production rate as a function of time curve for the formation can be obtained directly from the oil cut curve by using the injection rate and the volume of recoverable oil.

If the formation contains a free gas saturation, the free gas space must be filled before oil production will occur. Therefore, the oil production rate of the formation prior to breakthrough will be zero until the volume of water injected will equal the volume of the free gas space minus the volume occupied by the residual gas saturation. After fill-up of the free gas space, oil production rates should be divided by the formation volume factor to allow for the shrinkage occurring in the reservoir oil when it is brought to surface tank conditions.

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★ ★ ★

Humble Uses

Productivity Method to Evaluate Gun Perforating

Fort Worth, Tex.—In general, bullets have some advantage in soft formations while jets are more desirable in perforating through casing, cement sheath and into formations of high strength. These two points were the overall general conclusions of a talk by T. O. Allen, in charge of Humble Oil & Refining Company's perforating research, presented at the spring meeting of the Southwestern District of API held at Fort Worth, March 21-23, 1956. Allen presented the paper "Productivity Method of Evaluating Gun Perforating," co-authored with H. C. Worzel of Humble.

In summarizing the research project, Allen stated, "Extensive testing of jet perforators has indicated that fluid in the well and the direction of pressure differential between the formation and the well bore while perforating, as well as the design of the charge and gun, may significantly affect the productivity of the perforated completions. The tendency of some jet guns to plug perforations with copper carrots appears to be related to gun and charge design. When drilling muds are used as perforating fluids under simulated well conditions, perforations are filled with mud, sand, and charge debris; and these perforation plugs are not readily removed by production through the perforations. High productivities are indicated when perforating in oil or salt water with pressure differentials into the well bore using a perforator which does not cause carrot plugging. Testing of bullet perforators has proved that depth of penetration is a limiting factor with this type of gun when perforating casing, cement, and formations having high strength. When perforating with bullet guns in mud under simulated well conditions, some reduction in well productivity is indicated as a result of mud and sand in the perforation and of crushed and compacted sand around the perforations."

This method, now used by others, includes: (1) use of large-diameter formation cores, conditioned to specific hydrocarbon and interstitial-water saturations; (2) determination of effective formation permeability prior to perforating, immediately after perforating, and after cleaning the simulated well; (3) isolation of the simulated reservoir from the well by casing and a suitable cementing material; (4) perforating the test target, consisting of simulated well casing, cementing material, and formation, by an established perforating company with various perforating fluids in the well; (5) maintenance of reservoir and well pressure and temperature during and after perforating for a sufficient length of time to simulate normal field well completion; and (6) evaluation of test results. Table 1 shows a summary of perforator productivity tests, and Fig. 1 is a schematic diagram of the gun-perforator testing set-up.

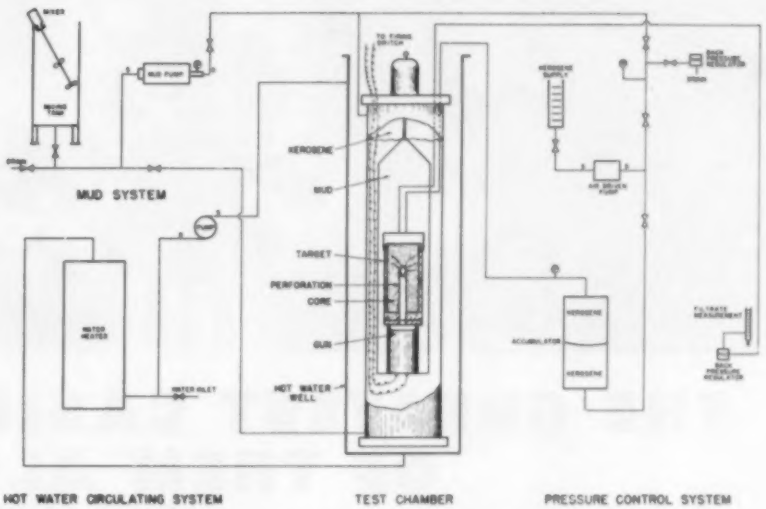


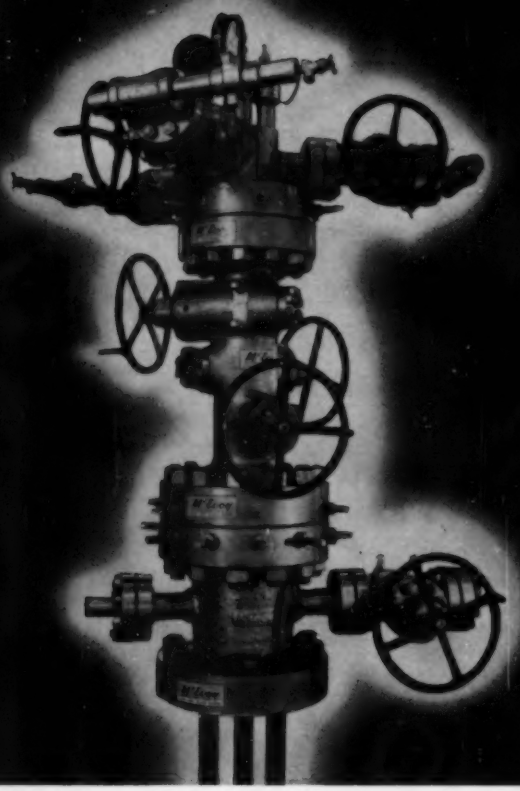
FIG. 1. Schematic diagram of Humble's gun-perforator testing setup.

TABLE 1. Summary of perforator productivity tests*

Type perforator, well fluid, and differential pressure	Perforation data: Penetration, in.	Perforation data: Hole size, in.	Average differential to initiate flow, psi	Average flow index†	Condition of perforation after backflowing
JET PERFORATOR					
10-lb salt water					
200 psi into well bore	6½ to 8	¼ to ½	0	1.00	Hole clean to total depth.
500 psi into formation for 3 to 10 hours	6½ to 8	¼ to ½	0	0.61	Hole clean or partially filled with charge debris and sand.
10-lb caustic-quebracho mud					
500 psi into formation	6½ to 8	¼ to ½	30	0.55	Partially or completely filled with mud and charge debris.
16-lb lime-base mud					
500 psi into formation	6½ to 8	¼ to ½	100‡	0.41	Completely filled with mud, sand, and charge debris.
BULLET PERFORATOR					
10-lb salt water					
500 psi into formation	3 to 3½	½	0	0.61	Cleaned out or partially filled with sand.
10-lb caustic-quebracho mud					
500 psi into formation	3 to 3½	½	30	0.53	Filled with mud and sand.

*Well and reservoir temperatures were 180 F. and guns normally used to perforate 5½-in. casing were used on all tests.
†For definition of flow index, see par. 4, page 6. Results of tests in which carrots plugged the perforations were not used in calculating these average flow indices.
‡Pressures as high as 430 psi were required to initiate flow in some instances.

THREE INDEPENDENTLY RUN PARALLEL TUBING STRINGS



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1954 CENSUS REVEALS

Salaries and Supplies Get Contractors' Dollar

Drilling and service companies now doing a $1.6 billion business annually, have increased receipts eight-fold since 1939

CONTRACT drillers and service companies received for services more than $1.6 billion in 1954, according to statistics just released by the U.S. Bureau of the Census.

Largest major expenditure in these industries was for wages and salaries — $541,000,000. Supplies cost $375,000,000, fuel and electric energy cost $59,000,000, $56,000,000 was spent for subcontract work, and $37,000,000 for products purchased for resale without further processing. The cost of purchased machinery installed during the year for use by the contractors was $168,000,000. Capital expenditures for new construction and new and used machinery amounted to $177,000,000.

Companies engaged in drilling oil and gas wells accounted for $920,000,000 of these total receipts, while rig builders received $11,000,000 and other oil and gas service companies received $634,000,000. These services mark an 800 per cent increase in 15 years.

These figures are the result of the 1954 minerals industries census. Contractors were requested to prepare a report of oil and gas field contract services performed in the United States. These reports were classified on the basis of the principal type of service performed and the principal state in which the service was performed.

Three oil and gas contract services industries are recognized by the Bureau of the Budget. First of these industries represents establishments primarily engaged in drilling wells for oil or gas; this category includes contractors specializing in spudding or drilling in services. The second industry represents firms building, repairing, and dismantling rigs and derricks. The third industry is defined as companies primarily engaged in performing the many miscellaneous oil and gas field contract services. This group includes those engaged in oil and gas field exploration;

TABLE 1. Principal statistics for the oil and gas field contract services industries in the United States, 1954.*

(Excludes establishments for 1954 with amount received for services and with expenditures less than $500).

*Taken from the preliminary report, 1954 Census of Mineral Industries, U. S. Department of Commerce.

Item		All oil and gas field contract services	Drilling oil and gas wells	Building, repairing, and dismantling rigs and derricks	Oil and gas field contract services, n.e.c.
Number of contracting companies		5,325	2,798	113	2,414
Amount received or due for services, total	$1000	1,565,121	920,038	11,276	633,807
Drilling oil, gas, dry, and service wells	$1000	890,433	885,983	..	4,450
Building, repairing, and dismantling rigs and derricks	$1000	12,306	123	10,348	1,835
Other services classified in these industries	$1000	597,907	22,885	335	574,687
All other receipts[1]	$1000	64,475	11,047	593	52,835
Value added in oil and gas field contract services[2]	$1000	1,046,488	561,358	9,233	475,897
Number of employees, total[3]		124,453	68,064	1,596	54,773
Production and development workers		110,574	61,649	1,502	47,423
All other employees		13,879	6,435	94	7,350
Man-hours worked by production and development workers	$1000	247,401	135,057	1,686	110,658
Principal expenses, total	$1000	1,068,723	670,775	7,259	390,689
Wages of production and development workers	$1000	449,288	267,989	4,668	176,631
Salaries of all other employees	$1000	92,146	43,851	457	47,838
Supplies	$1000	374,710	275,740	1,482	97,488
Fuel	$1000	57,978	34,751	294	22,933
Purchased electric energy	$1000	995	183	4	808
Subcontract work	$1000	56,243	40,990	187	15,066
Products purchased for resale	$1000	37,363	7,271	167	29,925
Purchased machinery installed	$1000	168,224	112,320	338	55,566
Capital expenditures (construction, machinery, and equipment)	$1000	176,880	112,575	429	63,876
For machinery and equipment only	$1000	172,097	110,682	373	61,042
Horsepower rating of power equipment[4]	$1000	7,991	4,207	39	3,745
Water intake[5]	1,000,000 gal	6,597	5,917	22	658

[1]Includes receipts for services not classified in these industries, such as hauling and machine-shop work; receipts for oil, gas, and other products of establishments in these industries producing such items as a secondary activity; and receipts for products purchased and resold without further processing.

[2]Represents total receipts plus capital expenditures less cost of supplies, fuel, purchased electric energy, subcontract work, purchased machinery installed, and products purchased for resale.

[3]For 1954, represents an average of four quarterly figures for the payroll periods ending nearest the 15th of March, May, August, and November.

[4]Represents the horsepower of all prime movers plus the horsepower of electric motors driven by purchased energy.

[5]Represents the intake of both fresh and barckish water from publicly and privately owned systems. However, excludes water furnished without charge by companies for which the contract work was done.

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Increase your profit margin on deep hole spudder operations with Bucyrus-Erie's heavy-duty tripod derrick. For use with both 36-L and 48-L spudders, this special derrick has sufficient height and stability to handle casing loads up to 300,000 pounds when rigged for 10-part hoist. Completely raised, the derrick is 70'4" high. Despite its size, you lose nothing in the way of spudder mobility.

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36-L Top-to-bottom drilling to 3,500 feet. Servicing to 4,000 feet. Swings up to 4,200 pounds of tools.

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1. Derrick sections are assembled on ground.

2. Legs are hinged to base and gin pole is in place preparatory to raising derrick.

3. Using bull reel drum for hoisting, derrick begins to rise.

4. Hinged front lower section is pulled into place by derrick hoist.

5. When derrick is completely raised, the gin pole is removed and the front lower section attached.

excavating slush pits and cellars; grading and building foundations at well locations; well surveying; running, cutting and pulling casing, tubing, and rods; cementing wells; shooting wells; perforating well casing; acidizing and chemically treating wells; cleaning out, bailing, and swabbing wells; and drilling water input wells.

Employment in these industries averaged 124,000 during 1954 — a threefold increase since 1939.

Total horsepower of equipment available to these industries is estimated at 7,991,000, a 900 per cent increase over that available 15 years ago.

Over one-half of the total number of companies surveyed were engaged primarily in drilling oil, gas, and service wells and accounted for three-fifths of the total receipts. These drilling contractors indicated that they performed work in 34 states in all geographic divisions except New England. Classified on the basis of "state of primary activity," drilling contractors are shown for 30 states. Over one-third of the total receipts, however, represented contractors classified in Texas, and about 87 per cent of the receipts by these contractors was for work in Texas. Contractors classified in Louisiana accounted for about 16 per cent of the total receipts by drilling contractors, those in Oklahoma for about 11 per cent of receipts, and those in California about 8 per cent.

During 1954, these companies drilled about 43,000 wells. This included about 26,000 oil wells, 3000 gas wells, 13,000 dry holes, and 1000 service wells. The total footage drilled that year was 167,000,000 ft. Cost of drilling these wells, borne by the contractors, was $683,000,000.

Only 2 per cent of the companies, according to the Census Bureau, were in the rig building, repairing, and dismantling business. These companies accounted for less than 1 per cent of the total receipts.

Less than 2 per cent of the companies were in the well surveying, well logging, and well cementing business, but accounted for 12 per cent of the total receipts for services.

About 6 per cent of the companies, accounting for 7 per cent of the receipts, represented establishments primarily engaged in geophysical and other exploration work. About 3 per cent of the receipts was accounted for by those doing acidizing and chemical treatment of wells. Another 3 per cent of the companies were engaged in perforating casing; 3 per cent did cleaning out, bailing out, and swabbing wells; and 3 per cent of the companies primarily ran, cut, and pulled casing, tubing, and rods. ★ ★ ★

"I told him it wuz a wildcat!"

The Nation's Wildcatters continue to set new records . . . and more new sources of production are uncovered. Whether it's a Wildcat rig or just another well in a proven territory . . . Joe Roughneck, symbolic figure of the oil industry, is making hole . . . or calling the shots from the home office where he has become head man.

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Cuba Is Photo-Mapped

Photo-mapping of the entire island of Cuba and adjacent islands of the Republic of Cuba was begun late in January. The air photos will be used for geologic studies and general reconnaissance by the oil and mining industries, as well as by engineering companies and others at work on Cuban development.

Two specially outfitted P-38 photographed Cuba's 44,000 square miles from a height of 35,000 ft. Each 9 by 9-in. photo covers an area of about 80 square miles; approximately 3000 photos were to be made. The photo scale is 1:60,000. The photos overlap about 56 per cent along the line of flight, much as shingles on a roof overlap, for maximum three dimensional effect when seen through a stereoviewer.

The P-38 covers about 4000 square miles per day, flying and mapping at a speed of over 300 mph. At heights of 35,000 ft the pilot and photographer are wholly dependent on the aircraft's oxygen system. The temperature is —60 F at this altitude, compared with Cuban ground temperatures of 85 F.

Two bases are being used for the air survey operation: Camaguey and Santiago.

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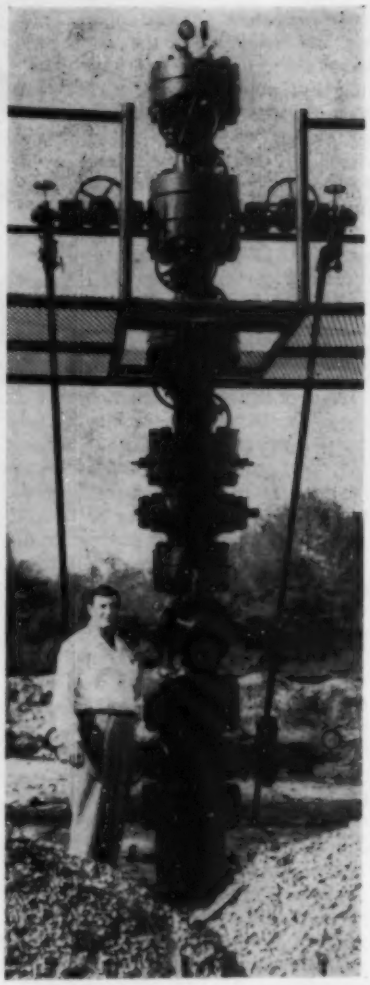

— Photo courtesy National Supply Company.

Southern Natural Uses "Super" Xmas Tree On Louisiana Gasser

In the heavily wooded "Cajun" country near Franklin, Louisiana, Southern Natural Gas Company recently installed a "super" christmas tree, believed to be the world's largest. It is a dual-ported valve assembly and extends nearly 20 ft above the ground. Some idea of the size of this tree is shown by L. A. J. Monroe, district manager of National Supply Company, New Orleans, standing beside the huge assembly.

The casing program on this well included 13⅜-in., 9⅝-in. and a 7-in. liner. Both tubing strings are 2⅞-in. external upset ends, 8-round thread. One string of tubing was set at 11,500 ft, with a production packer and the other was jung open-ended at 9500 ft. Flowing tubing pressure is approximately 2500 psi.

get more BIG MONEY WELLS early in the program with

BLACK MAGIC

Time after time in a field development program, oilmen wait too long to learn the big money benefits of completing with Black Magic. By the time they've found out how no formation damage and maximum permeability can pay off in high production, they're down to their last location or two in the field. One test well usually shows how Black Magic oil base drilling mud can increase production... often by 100% or more compared with water-base-drilled wells. Then they wish—too late—that they'd found out sooner.

Profit by the example of those "too-late" oil-basers. Start completing wells early in your development program with Black Magic, world's leading oil-base mud. Black Magic is the drilling fluid that loses NO water to the surrounding formation. Therefore Black Magic cannot introduce water block or Jamin action into the formation to lower return permeability. That means maximum possible production right from the start, as clearly shown by world-wide production records on Black Magic completions vs. water-base completions.

Completion isn't the only operation in which Black Magic can do a better job for you. Black Magic cuts drilling cost and time, because it lubricates the bit and the hole, and does not trigger heaving shale or other hydratable formations. In many problem locations Black Magic can pay its cost many times over by ending costly drilling troubles.

More than 10,000 Black Magic jobs are the best recommendation for its trial and use. Contact your OBI representative today.

WIN $100.00!

A cash prize of $100 will be awarded for the best one page letter entitled, "Where we should have used Black Magic... and didn't." All entries should be postmarked before midnight, April 30, 1956, and will become property of Oil Base, Inc. Decision of judges will be final. Ask your OBI representative about further details or mail entry to Oil Base, Inc., 130 Oris St., Compton, California.

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Salt Dome's Drilling Crews Live On . . .

A Motel At Sea

- **Prefabricated quarters handled as one "packaged" unit.**
- **Modern facilities ease duty on offshore structures.**

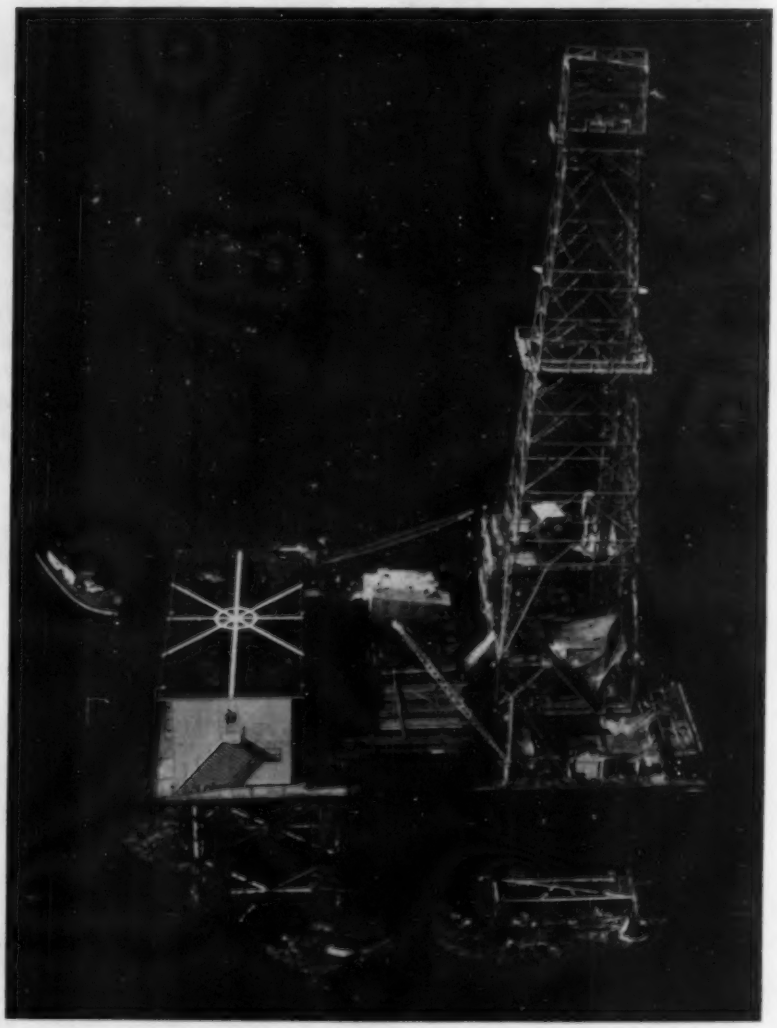
THE air-conditioned, 46-man crew quarters on Salt Dome Production Company's platform in the Gulf of Mexico south of Cut-Off, Louisiana, surpasses most of the first-rate hotels in the U.S. An expert interior decorator designed the furnishings and color scheme, and the stainless-steel galley makes cooking such a pleasure that meals are always good.

The TV, pleasant surroundings, and tasty in-between-meal snacks greatly reduce the tedium of the off-duty hours for crews who must spend 10 days or so at a stretch on the man-made island. Crew morale is high; and as every tool-pusher knows, this is one of the keys to good safety records and efficiency.

Ordinarily, the unchanging scene of sky, water, and same faces is difficult for most men to tolerate days on end. To many crew men working in the Gulf, the platforms seem to get smaller and smaller as the offshore tour drags out. Small inperfections in food and lodging tend to become magnified in their eyes and sometimes bring on downright disgruntlement.

This is why Offshore Specialties Company used such care in designing this quarters structure for Salt Dome. The walls of porcelain steel are painted light green, and the recreation rooms have large picture windows that dispell the idea of a "bunkhouse."

The 30x80-ft two-story building has two 12-man dormitories, three 4-man bed rooms, two 2-man executive bedrooms and one 6-man bedroom for caterers. It has a complete toilet, shower and washroom for every 6 men on board, and with the galley included, there are 4800 sq ft of living space.



The "Coptel" is a combination crew quarters and heliport shown at left on Salt Dome Production Company's offshore structure.

no tubing weight needed to set!

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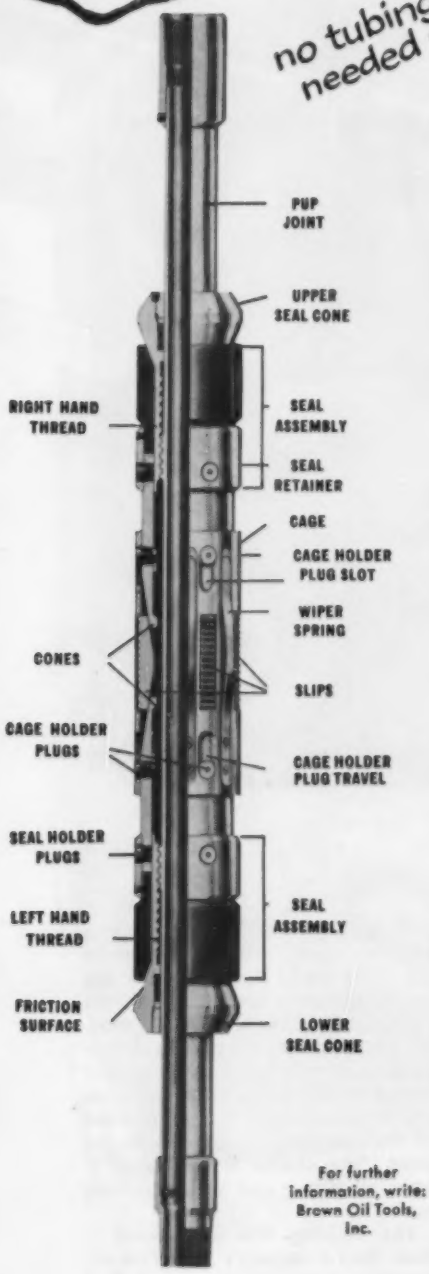
more than 500 Brown B-4 Packers in use ....



Three years ago Brown Oil Tools developed the Brown Type B-4 Mechanical Set Packer to fill the need for a packer that could be set in tension and needed no tubing weight to set. We appreciate the acceptance of this packer by the oil industry — as evidenced by the more than 500 Brown B-4's in use today.

The main application of the Type B-4 Mechanical Set Packer, which has proved satisfactory under the requirements made on any conventional production packer, is in wells in which it is desired that no tubing weight be set on the packer or when it is desired to set the tubing in tension. It is also applicable on high pressure single completions, wells equipped with bottom-hole chokes, in a dual completion with a high pressure lower pay; and as the top packer in a two packer type dual completion, particularly when cross-over flow equipment is used.

can be set in tension!

IF YOU HAVE A PACKER PROBLEM — BROWN CAN HELP

BOT

For further information, write: Brown Oil Tools, Inc.

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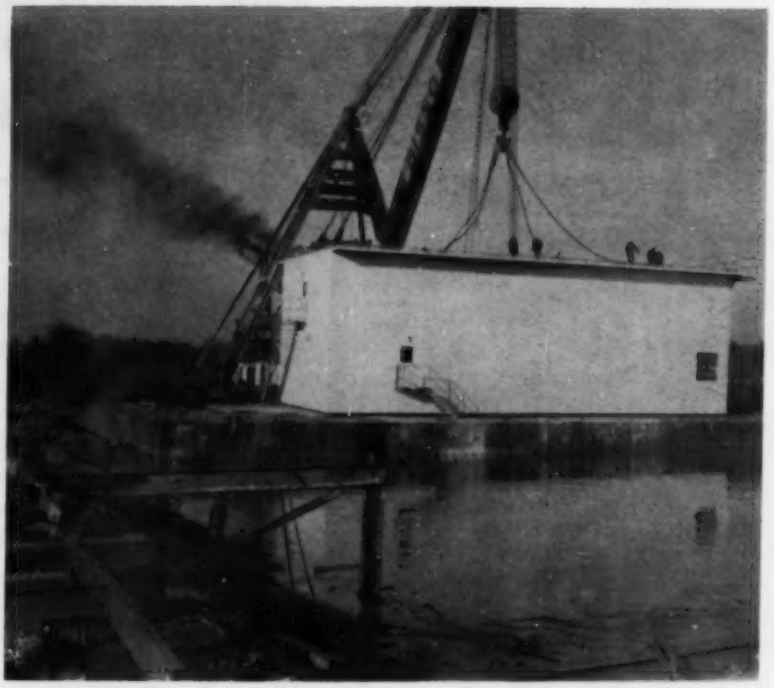
Most remarkable thing about the building is its great internal strength. Although it weighs 160 tons, a derrick barge can handle it as easy as a cracker box. It can be lifted with no spreader bars from pad-eyes at each corner. In a sense, this makes it the world's first portable "motel" since it can be easily moved to any platform that can be reached by a derrick barge. As a matter of fact, it can be loaded off the platform into a barge in a matter of minutes.

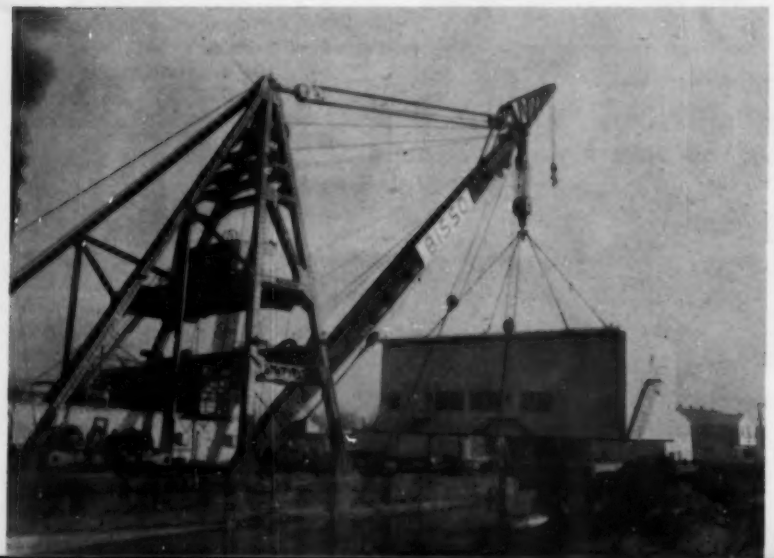
The designers refer to the structure as a "Coptel" because of the 38x80-ft helicopter deck on the roof.

Expansive bay windows in crew quarters dispell a feeling of confinement during the long tour of duty on the offshore structure.



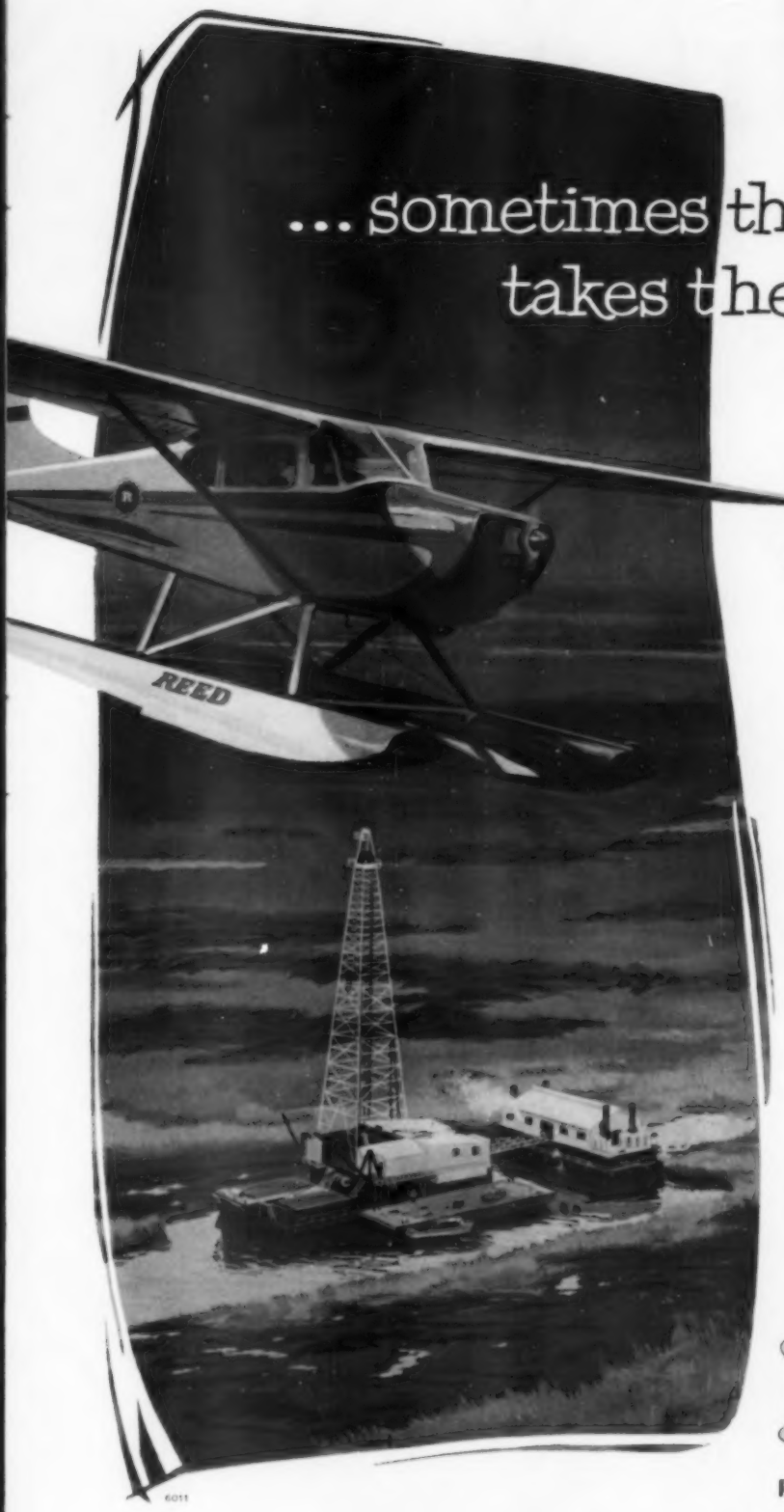
Crane easily lifts 160-ton prefabricated unit for loading onto barge for transport to offshore structure.

Front side of "Coptel" showing broad windows in recreation room. Spreader bars not required in lifting, as structural design incorporates "pad eyes" for lifting purposes.



While the "Coptel" is not exactly a sea-going vessel, it does come under U.S. Coast Guard regulations. For this reason, Offshore Specialties followed USCG specifications as to lighting, etc. The building is fire-proof with porcelain steel walls inside and out and fiber-glass in between. Little wood was used in its construction, and the floors are vinyl tile except in the showers and galley. The ceiling is suspended to cover all wiring and air-conditioning ducts.

The building was constructed in Hunt Tool Company's New Orleans, Louisiana, yard. ★ ★ ★



... sometimes the Reed Man takes the high road!

A familiar sight in the marshlands of Louisiana is the Reed plane . . . bringing the Reed man and his knowledge of rotary drilling tools to a drilling barge.* His transportation may be unusual but the contact with isolated rigs to learn their needs and offer time- and money-saving advice is a regular part of the Reed man's work . . . a task which is daily routine.

Onshore or offshore . . . on a mountain side or in a marshland . . . you can be certain the Reed man will get to your location by whatever means of transportation will get him there at the time he can be most helpful.

* Reed initiated this service in 1950 to become the first oil tool manufacturer to have its own plane for regular contact with water-location drillsites.

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ROLLER BIT COMPANY

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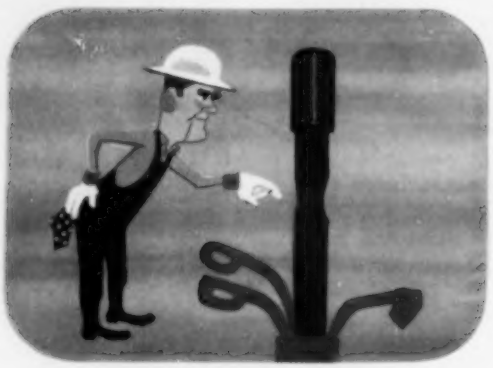
. . . right at the

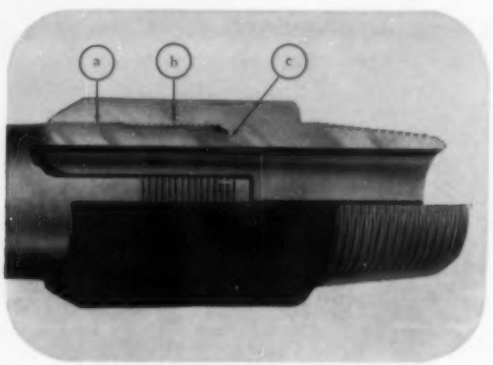
Take a look at the tool joint that's right for your rig



1. **Longer Tool Joint Life:** When pipe must be discarded, the tool joint can often be saved. Field replaceable joints are removed from old pipe, applied to new . . . *right at the rig!*

2. **Saves Time and Money:** No need to shop pipe to change joints. After long service (or accidental damage) tool joints can be replaced . . . in minutes . . . *right at the rig!*

4. **Foolproof:** Reed's crew or your own men simply screw the heated joint onto the drill pipe until the landing shoulder strikes the end of the pipe with a "jar." The landing shoulder is a positive gauge to determine proper application of the tool joint.



5. **Here's the Payoff:** As the tool joint cools, the shrink-grip area (a) and the landing shoulder (c) form perfect seals . . . since the correct amount of shrinkage has been built-in at the factory . . . to protect the threads (b) against leaks and corrosion.

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6. **Practical and Trouble-free:** With both interior and exterior access to the threads fully sealed and the land preventing creeping, the threads are protected against galling, leaks and corrosion—thus making it practical to replace the joint in the field.

TOOL JOINT!

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EUROPEAN COMPETITION For Oilfield Equipment

Since World War II, more foreign manufacturing facilities installed. Sales for second quarter, 1955, total $9,000,000

William T. Powell
President
Emsco Manufacturing Company
Los Angeles, California

TO avoid confusion, I want to say at the outset that my comments are limited to the manufacturing of drilling and producing equipment for the oil fields. Also when I talk of European manufacturers, of necessity, I must exclude all equipment from Iron Curtain countries, even though there is some evidence that this can be a source of potential competition in future years. Because the United States has been a pioneer in the manufacturing and development of oil field equipment, experience in this line is predominantly the specialty of United States companies. Nevertheless, oil field equipment has been manufactured in Europe for many years.

Prior to World War I, European equipment was used in the Roumanian, Polish, and Russian oil fields. Some of the early work in Latin America was done with cable tools that were produced in Europe.

At the end of World War I, several English firms decided to manufacture oil field machinery. By 1930, the number of companies was greatly reduced. Shortly before World War II, manufacturers of these products were limited to England, Holland, Germany, and to a smaller extent, Italy. Those companies that survived either manufactured as licensees of United States manufacturers, or they were dealing with purely local markets. In some instances, the equipment was purchased by companies whose main purchasing offices were in countries where the equipment was being manufactured.

The decline in European manufacturing was largely because foreign operators preferred United States equipment. United States equipment was preferred, first, because it was of more modern design and, second, it was field tested. The only exceptions were where dollars were not readily available or local policy directed that purchases be made within the country concerned.

Interest rises after World War II. At the end of the Second World War, an even greater interest in the manufacture of oil field drilling and producing equipment was evidenced in Europe. Many European countries had been unable to purchase equipment for six or seven years and because of the war were unable to do any development of their own. Also the currency problem had become acute, so it appeared that the circumstances for manufacturing after World War II were much more favorable than in 1930.

About 1949, the British manufacturers organized the **Council of British Manufacturers of Petroleum Equipment,** an organization similar to our **Petroleum Equipment Suppliers Association.** Within the last few years, a second association has been formed to include most of the European manufacturers. It is my understanding that the British council, although a separate group, has representation on the European council.

Equipment sales climb. For the second quarter of 1955, from where the latest figures are available, the British council reported that sales of "special equipment for oil drilling and producing, including oil well casing and tubing, totaled approximately $9,000,000". I do not have a detailed breakdown, but I feel it would be safe to assume that a large percentage of this was in casing and tubing.

There are about 290 rigs in operation outside of the Americas. These rigs range in size from the **Failing 15** to the **Emsco 1400** or the **National 130.**

British makes variety of equipment. The United Kingdom today can and does produce almost any kind of equipment for the drilling and producing of oil wells. Some companies are manufacturing to original United States designs or have copied United States designs. A majority of the equipment sold is that of United States design manufactured by European affiliates or under license.

The domestic market in England is small. The latest report shows six rigs running. From this, it is obvious that the domestic market in England will not support the industry.

Germany self-sufficient. About 70 rigs are reported running in West Germany. As in the past, West Germany is largely self-sufficient in the equipment field. Most are of native design, with the possible exception of rock bits. It is my understanding that Germany has been able to make and supply its domestic market from domestic sources with practically all rigs and very few have been imported. Likewise, very few German rigs have been exported to other countries.

Italian facilities increasing. It is reported that Italy has about 28 rigs running at this time. Two manufacturers currently make rotary drilling equipment and a third has been reported to have been licensed, but is not yet in production. Even so, it is estimated that not more than 30 per cent of the rigs in operation in Italy were manufactured there. Manufacturing is limited to drilling machinery, including slush pumps. Because of the relatively small market

and high development cost, Italian equipment measured by U.S. standards gives the appearance of being antiquated.

France makes little. France reports 24 rigs running, all of which were imported either from United States or England. To my knowledge at the present time, they make only slush pumps and some specialty items.

Only pumping equipment in Holland. Five rigs are reported operating in Holland. As far as I know, Holland does not make any drilling equipment, but does manufacture pumping units and bottom-hole pumps. Both the pumping units and bottom-hole pumps are being operated in foreign areas, but purchasing for these items is done in Holland.

Yugoslavia reports 12, Spain 3 and Portugal 2. To my knowledge no equipment is being made in any of these countries.

Austrian picture confused. The Austrian picture is a little confused at present because some of the oil properties are in the process of being returned to the original owners. Sucker rods, slush pumps, and pumping units are currently being made in Austria. The rods are an alloy grade, and it is my understanding that almost the entire production is being sold in South America — mostly in Venezuela and some in Argentina.

Foreign drilling activity. From this, it can be seen that at this time Western Europe is operating about 164 rigs. This is fewer than is currently operating in the state of California.

North Africa has about 35 rigs running with no manufacturing facilities. Most of these rigs are of American design and manufacture.

There are about 36 rigs in the Middle East. Here again, there are no manufacturing facilities, and it is probable that 50 per cent are of British manufacture.

There are about 40 to 45 rigs operating in Asia, and the probabilities are that at least 80 per cent are of British manufacture.

Australia has 9 rigs, most of them being of United States manufacture.

Little foreign equipment sold in U.S. Other than small shipments of pipe in times of shortage, very little European material has been sold in the United States.

Some production machinery has been shipped into western Canada, but, by and large, the European manufacturer has not been able to make much headway in this traditional United States market.

The Latin-American Market. Thus, in order to achieve permanence and avoid the trouble of the "between wars period," the European manufacturer must turn to the only remaining market that is available to him—the Latin-American market. This market has been dominated by U.S. manufacturers.

European equipment is already being purchased, particularly for Venezuela and Colombia, where either the oil company purchasing power is located in Europe or where money exchange is more favorable. It would appear, therefore, that the market which the European manufacturer must reach if he is to survive is that of federally owned oil operations in Central and South America where production is still largely undeveloped and where the companies are either short of dollars or cannot obtain necessary U. S. credit.

Credit and barter offered. Several European countries, notably Italy, France and West Germany, are offering long-term credit to these countries. In some cases, it is offered for a period of five years in order to stimulate European manufacturing. Barter is also being considered in order that the products produced by the Latin-American countries can be exchanged for European merchandise. Germany, particularly, is reported as offering extremely long credit to South America.

Because operators in Latin-American countries have a preference for

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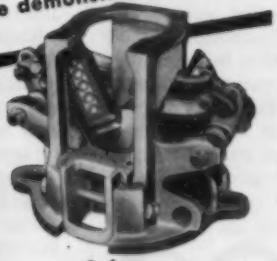

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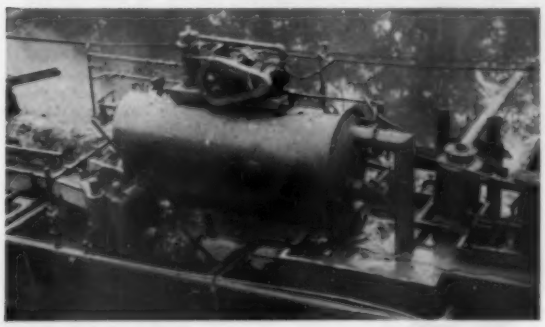

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U.S. design, it would appear that equipment made under United States licenses by European manufacturers would have a distinct advantage over the so-called copies; nevertheless, extended credit might be the determining factor.

Contract drilling is on the increase in foreign fields. In many cases, the contractor is taking at least partial payment in local currency. It would appear that the European manufacturer might make sales to this class of customer. Oil companies frequently have local currency to spend and some companies have the policy of wanting to spend part of their earnings in the country in which the earnings were made.

Prices not comparable. With one or two exceptions, to date the European manufacturer has not been able to produce equipment at a price comparable with United States even though labor rates in European countries are lower. In my opinion, therefore, any growth, or in some cases, survival, for the European manufacturer in the drilling and producing equipment field must be in Latin America. To do so, sales to these countries must be made either through barter or on extended terms, possibly with their government support. I cannot help but feel that because of the currency problem, we will see extended competition along these lines.

Iron Curtain products. Earlier I commented on Iron Curtain country manufacturers. I saw recently that Roumania was exhibiting a 1500-hp drilling rig at the Indian Industrial Fair and that smaller sizes were also being offered. Included in the Roumanian list were such items as drawworks, mobile hoists mounted on trucks, rotary tables, slush pumps both power and steam, rock bits, subsurface pumps, gas and oil separators.

It was reported that the Indian government had already ordered Russian survey equipment and drilling rigs. However, the size of the order had not been disclosed. These countries could also, and probably will, attempt to enter what has been traditionally United States export markets.

Competition to grow. It is my opinion that in the export areas I have outlined, we can expect much greater competition in the next few year than we have experienced in the past. I have no recommendations as to how this challenge should be met, believing it to be the responsibility of the individual company.

Acknowledgment

This article was taken from a talk delivered by the author to the Los Angeles Chapter of NOMADS, December 14, 1955, and based on an extensive trip made by the author earlier that year.

★ ★ ★

The Author

William T. Powell is president of Emsco Manufacturing Company with headquarters in Los Angeles, California. This story is based on an extensive European trip he made in 1955. A native of Wales, Great Britain, he was graduated from South Wales and Monmouthshire School of Mines in 1923 in mechanical engineering. He later did post graduate work at USC. Powell came to the U. S. in 1929, and in 1937 joined Emsco as chief engineer of the fabricating plate department. Since that time, he has been manager of the war materials division, made a vice president of manufacturing in 1945, and later the added responsibility of engineering. He was made executive vice president in 1951, and in 1952 became president. He is also chairman and a director of Emsco's British-operated subsidiary, Emsco Engineering Company, Ltd. He is currently president and a director of Metal Trades Association of Southern California and a director of The Petroleum Equipment Suppliers' Association.

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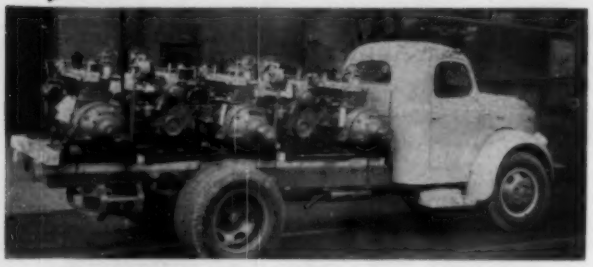
MEMO- Clutch must maintain it's torque



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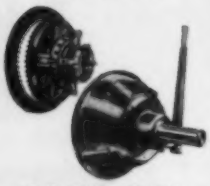

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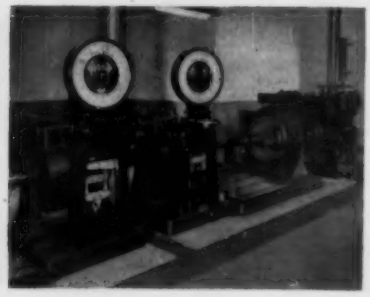

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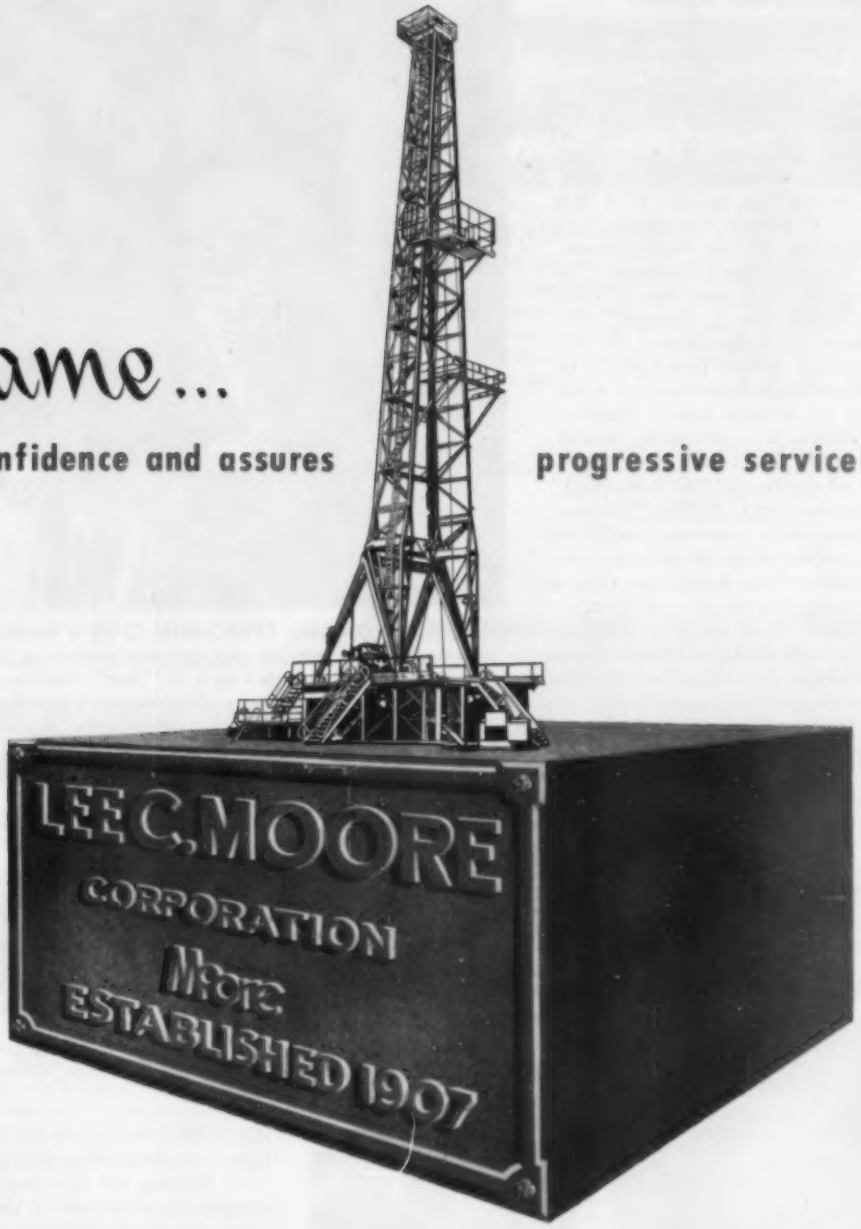

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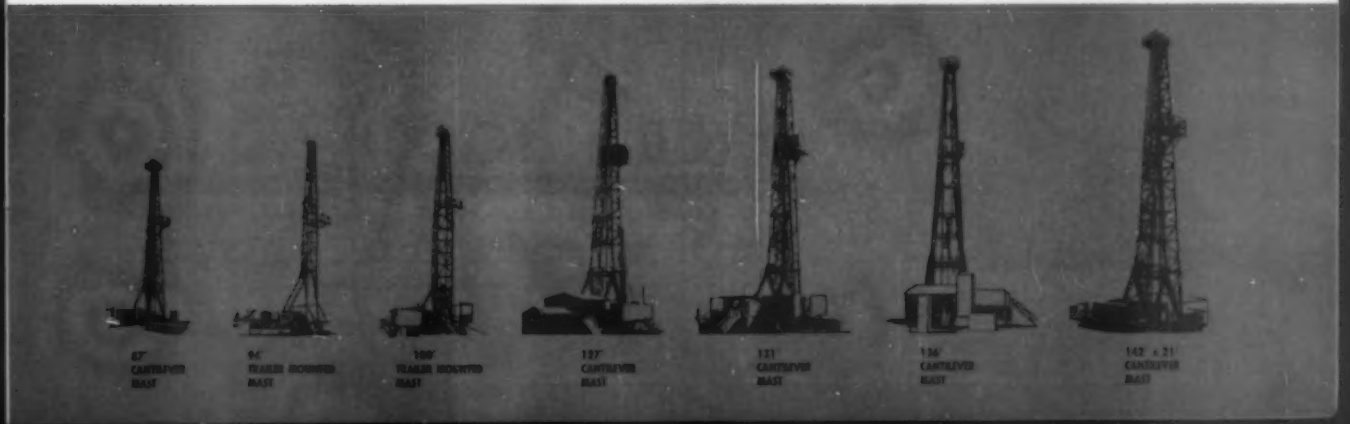

Roughnecks Get Portrait

With 30 chapter members being named by an anonymous committee, the Roughneck's Club of Casper, Wyoming, was organized on February 14, 1956.

Charter members of the Casper Roughneck club are H. A. True, Jr., M. E. Peden, Sam Rogers, W. J. Williams, A. O. Bullock, Guy Keith, D. E. Bland, Henry T. Gist, Tom Grannell, R. E. Tinsley, John J. Oldham, G. E. Stevens, M. M. Brown, Sam T. Dyer, Gabe McCall, W. G. Tschudin, Fred Goodstein, J. D. Sprecher, J. M. McIntire, M. J. Boyce, Tom LaMor, Joe Fusselman, J. D. Simmons, H. B. Gernert, G. A. Isaacks, John J. Sullivan, John Roden, C. J. Matthews, Ray A. Sing, and R. M. Olds.

An oil painting of "Joe Roughneck" was presented by L. D. "Red" Webster, vice president of Lone Star Steel Company, sponsor of the Roughneck Club.

Purpose of the Roughneck Club is to recognize the pioneers of yesterday and today whose perserverance and courage have made the United States the world's leader in petroleum. The individual plaques denote that the recipient has rendered rough and rugged service in the field and has achieved a place of honor in the oil industry.

CASPER, WYOMING, PETROLEUM CLUB is the first to own an oil portrait of "Joe Roughneck," storied and dynamic symbol of the petroleum industry. The big painting was presented by L. D. "Red" Webster, vice president, Lone Star Steel Company, left, and was accepted for the club by Ray A. Sing, president, center. R. L. Gibbins, administrative assistant in Lone Star's sales department, right, presented individual Roughneck Club plaques to 30 charter members of the newly organized Casper chapter.

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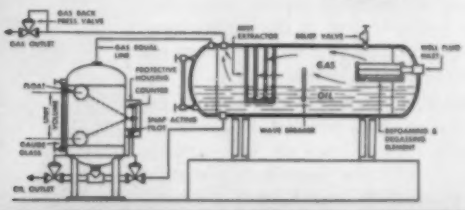
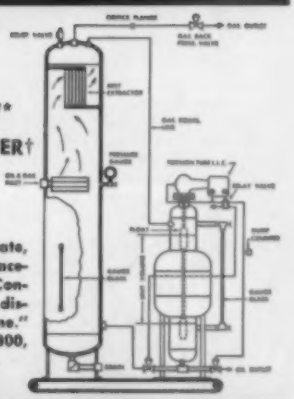
float actuated snap-acting pilot (exterior mounted for in-operation liquid level adjustment) controls inlet and outlet valves. Working pressures, 125 and 300 psi.



Because of field-proved accuracy, VOL-U-METERS† are approved as test units and for oil royalty and tax payment measuring: especially adaptable for automatic lease operations. Shipped assembled for ready use, standard applications are with oil and gas separators, emulsion treaters, oil, gas and water separators. VOL-U-METERS† feature: ease of installation • trouble-free and low-cost operation • sizes from ¼ to 10.0 barrels per dump • Barrels-per-day capacity, 288-4,000 • Accuracy, depending on model and size, 99.01% - 99.99%.

TYPE BV* VOL-U-METER†



equipped with simple, accurate, dependable positive-displacement type Liquid Level Controller, easily adjusted to discharge exact "Unit Volume." Working pressures: 125, 300, 600, 1200, 2000, 3000 psi.

For more information on the most accurate liquid-metering method available, write:

†Trade Mark *Pat. Applied For

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THE OASIS — *A gathering spot for NOMADS*

Franklin Named Chairman; Childs is Secretary-Treasurer

R. K. "Bob" Franklin of Houston, president and founder of Rolo Manufacturing Company, has been named chairman of the national board of regents of the Nomads. Succeeds James D. Hughes, with Lane-Wells in Los Angeles, and assumed office March 1.

Franklin's being named to the national chairmanship represents another step in his lifetime in the oil business, the culmination of which has been his own company founded in 1945.

His first oil field job with Sun Oil Company was landed because he looked 19, although he was actually only 14. In a few years he was operating production near Kilgore for independent producer R. C. Lipscomb, and by the time of his graduation from Kilgore High School he was a regular employee of Shell Oil Company.

In 1936 he joined Union Oil of California near Los Angeles as a field operator. It was here he began to develop the interest in metering oil well production that was the foundation work for his present company, Rolo Manufacturing.

He is a former national regent of Nomads, past president of the Houston Chapter, national member American Petroleum Institute, and the AIME.

R. K. (Bob) Franklin

W. L. (Bill) Childs, Jr.

W. L. (Bill) Childs, Jr., of Reed Roller Bit Company has been elected to the office of secretary-treasurer of the organization for the year beginning March 1, 1956. He holds a B.S. in petroleum engineering from the University of Texas.

He joined Reed Roller Bit shortly after his graduation, serving as salesman, sales engineer, sales division manager, and since November, 1952, as sales manager.

Mr. Childs has been active in Nomads affairs since 1946, serving as president of the Houston Chapter in 1955, and being elected junior regent of the Chapter for 1956.

NINETY-SEVEN NOMADS and guests greeted the new administration of Houston Chapter Nomad president W. O. (Bill) Hedrick at College Inn Monday, February 14. Warren Baker, Gulf Publishing Company, was the main speaker for the evening. Baker presented a forecast on oil industry activity for 1956. Nomad guests for the evening are shown seated, left to right, Bill Boren, Rolo Manufacturing; W. B. Jeter, Hardy-Griffin; H. R. Stephen, National Supply Company; Warren Baker, editorial director, World Oil; Jorge T. Lavandez, Coper Ltd., Lapaz, Bolivia; Gene LaSchober Jr., Bethlehem Steel; George R. Grim Jr., Manabi Exploration, Ecuador; Dewey Clark, Southeastern Asia Drilling Company. Standing, left to right, W. O. (Bill) Hedrick, president; F. B. Allary, Cameron Iron Works, Dallas; J. M. Gray, McCullough Tool; John Hardy, Hardy-Griffin; Cecil Smith, Gulf Publishing Company; B. Stark, Cameron Iron Works; Fred Buckner, B-J, Lake Charles, E. O. Koberg, B-J.; Eduardo Rugamo, Mexico D. F.; Horacio De la Concha, Cameron Iron Works; Stan Kazar, Hutchison Manufacturing Company. Last year's president, Bill Childs, has been named national secretary-treasurer.

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TRAVELING BLOCKS AND HOOK BLOCKS

OVER 45 YEARS EXPERIENCE

MODEL HT-100 HOOK BLOCK
WITH TWIN EAR ELEVATOR HOOK

The Best Blocks

FOR TOP-TO-BOTTOM SERVICE IN MAST OR DERRICK

Whatever your drilling requirement – whatever the type mast or derrick – there is a matched Brewster Traveling or Hook block that will speed up your round trip time. Built for years of rugged service, Brewster blocks have big oversized parts that assure an extra margin of safety to handle shock or heavy emergency loads. They are streamlined and balanced with low center of gravity for straight line travel.

The product of over thirty years of continuous improvement and development, Brewster blocks are now available in a range of capacity from 50 to 500 tons.

Ask your supply house for Brewster traveling blocks, hook blocks and matching crown blocks – or write direct.

Outstanding Features

TRAVELING BLOCKS

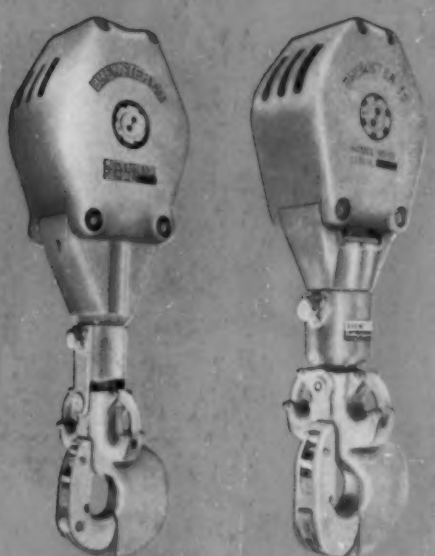
90 to 500 Tons

TIMKEN TAPERED ROLLER BEARINGS eliminate side thrust on sheave hubs.

CENTER PIN made of heat-treated alloy steel – rifle drilled holes for lubricating individual bearings.

SHEAVES made of alloy steel, accurately machined to A.P.I. specifications – grooves are flame-hardened.

ROUNDED CORNERS, COUNTER-SUNK BOLTS permit block to travel smoothly without danger of fouling.



CROWN BLOCKS

100 to 500 Tons

The practical rugged design of Brewster Crown Blocks has made them first choice with many contractors. Sheaves are cast of alloy steel, grooves machined to A.P.I. specifications with flanges hardened to reduce wear. Each sheave is mounted on double-row tapered roller bearings and is individually lubricated.

HOOK BLOCKS

50 to 100 Tons

Unitized for High-speed Mast Service. Brewster Hook Blocks are unitized assemblies combining the block, spring-loaded link adapter and hook in one short unit. The added headroom gained by this design permits faster operation in masts or short derricks as the pipe may be hoisted safely at full speed to the top of run. Free swiveling on roller bearings, the hook can be locked in any one of eight positions. The improved swivel lock has two ears to permit easy operation by reach rod from the derrick floor. Sheaves are mounted on double row Timken tapered roller bearings. The hook is made from tough Chrome-Nickel-Moly steel.

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1956 OFFICERS of the Los Angeles Chapter of Nomads at the Seventeenth Annual Inaugural Ball held at the Hotel Statler, Saturday, February 11. From left to right: H. J. Schlarb of Emsco Manufacturing Company, junior regent; H. Murray Walker of Lane-Wells Company, deputy sergeant-at-arms; John McEwen of Stansbury, Inc., assistant secretary; William C. Brooks of Byron Jackson Company, sergeant-at-arms; Robert P. Gaylord of Wagner-Morehouse, Inc., secretary; Tom G. Martin of R. J. Eiche & Associates, vice president; Harry Hester of McCullough Tool Company, president; James D. Hughes of Lane-Wells Company, master of ceremonies. Not shown: H. Rex Collins, Jr., of Hydril Company, treasurer; John S. Page of Page Oil Tools, Inc., assistant treasurer; John H. Flanagan of Johnston Testers, Inc., senior regent. Some 621 Nomads and guests gathered for the annual event.

GUESTS at the March 5 meeting of the New York Chapter were: (left to right) seated, A. L. Almoina, G. E. Failing Company; I. Wood, Esso Standard Oil Company; L. D. Josephson, California-Texas Oil Company, Philippine Islands; G. F. Birkett, British Petroleum Company, and J. E. Anderson, British Petroleum Company. Standing, T. Tucker, G. E. Failing; G. A. Koscioluk, Socoil, Argentina, and P. Docksey, British Petroleum Company.

INCOMING PRESIDENT of the Los Angeles Chapter Harry Hester, McCullough Tool Company, expresses appreciation of his election at the chapter's seventeenth Inaugural Ball February 11. Below, Retiring President H. J. Schlarb, Emsco Manufacturing, is presented with a gavel to commemorate his service last year by James D. Hughes of Lane-Wells, retiring senior regent.

Nomads Meeting Dates and Secretaries

New York Chapter, first Monday of the month, Hotel Roosevelt, New York. Executive Secretary E. W. Hoeppner, in care of Hughes Tool Co., Room 4414, 30 Rockefeller Plaza, New York 20, N. Y.

Houston Chapter, second Monday. Ye Olde College Inn, Houston, Texas. Executive Secretary, Harry E. Estes, P. O. Box 14343, Houston 21, Texas.

Los Angeles Chapter, second Wednesday, Jonathan Club, Los Angeles, California. Executive Secretary, W. A. Sawdon, P. O. Box 848, Hollywood 28, Calif.

Tulsa Chapter, third Friday, Mayo Hotel. Executive Secretary, E. L. Thomas, P. O. Box 4033, Tulsa, Okla.

Dallas-Fort Worth Chapter, first or second Monday. Secretary, H. A. Davis, H. A. Davis Power Equipment Company, 2142 Irving Boulevard, Dallas, Texas.

Fishing is a serious

Tri-State's new Washover Drill Collar Spear is the most outstanding tool that has been developed in the last 20 years.

Stuck in a Keyseat!

This was shocking news for a contractor to get from his Tool Pusher prior to the development of the Tri-State Oil Tool Company. Getting stuck meant washing over and often, dropping the heavy string of drill collars causing the walls of the hole to collapse behind them, knocking the cones off the bit and corkscrewing an expensive string of drill collars. More important, the drill collars would have to be fished out and the bit cones and the bearings retrieved. The operation could take from three to four days or weeks of additional fishing, cause a junked hole – or both. With the TRI-STATE WASHOVER DRILL COLLAR SPEAR there is no problem. The drill collars are washed over, caught, and brought out of the hole with no damage to the drill collars or to the hole.

New tools are always targets for many questions. In regard to the Tri-State Oil Tool Company's new Washover Drill Collar Spear, questions are always most welcome. Some of the more popular questions are discussed below:

How Will This Tool Save Me Money?

As all oil men know, rig time is money, and Tri-State's new Washover Drill Collar Spear can save many hours in time. For instance, with this tool, all of the washing over operation is done with the Kelly Joint. On the other hand, using a conventional dog overshot, the kelly must always be kept above the rotary and the drilling done with chain tongs, clamps and back-up post. If you let the kelly get below the rotary and the dog overshot passes a tool joint, the drill pipe cannot be picked up to make a connection. With the Tri-State Washover Spear, the drill pipe may be picked up any distance any time, as the tool is completely releasable.

Rotary Jars are often run above the wash pipe and, before picking up and making each connection we have found it a good practice to set the Washover Spear and trip the jars which will often free the fish, eliminating further washing over.

With this tool, Bumper Jars may also be run in addition to the oil jars. These are used to bump the wash pipe back down should it hang up coming out of the hole. This is very important when fishing directional holes.

Long and costly stripping out operations may also be eliminated for another time saver. When the wash pipe is brought to the surface with the fish inside, it usually takes about six hours of hard and dangerous work to strip the wash pipe off the fish when using conventional tools. With the Washover Spear, all that needs to be done is to pick up the drill pipe and screw it into the top of the tool with chain tongs, pick up and release the tool, lower the tool to the control bushing at the bottom of the wash pipe, set control lugs in the control bushings or set the slips on the tool, and back the drill pipe out of the tool. Then come out of the hole with the drill pipe. The wash pipe may then be brought out of the hole as if there were no fish in it. This operation usually takes about 1½ hours of relatively easy work – 4½ hours of rig time saved!

TRI-STATE OIL TOOL CO.

Main Office:

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and expensive business

Don't Drop That Fish...

All fishing tool men and most oil men familiar with washover procedure know that a rotary shoe will last much longer if none of the drilling fluid is diverted through the fish and bit. Many times it is necessary to plug the fish so that none of this fluid will be diverted through the fish. Ample space has been provided between the tool and the wash pipe so there will be no undue pressure build-up above the tool and all the fluid can go directly to the rotary shoe where it is needed.

After the washover is complete and the fish is being pulled out of the hole, the bit will often hang up, especially in lime sections. Often the bit hits these tight sections hard enough to stick and support the weight of the fish. The normal procedure is to lower the wash pipe and bump the bit with the rotary shoe. This problem illustrates another advantage of the Washover Spear. With a conventional dog overshot, the fish can fall as much as the length of a joint of drill pipe. This often shears the dogs out of the overshot and the fish is lost again. With the Washover Spear, the fish *can never drop over 4½ feet.*

Why Is the Fish Allowed to Drop 4½ Feet?

This space is needed should the rotary shoe start to "bind" making it impossible to turn the wash pipe string. The pipe may be picked up three or four feet and the shoe turned to free it up without disturbing the tool. We have learned by experience that this drop causes absolutely no damage to the drill pipe, wash pipe or the tool. We have washed over and caught as many as eighteen 6¾" drill collars without damage whatsoever.

Is the Tool Used Only When the Pipe Is Stuck Off Bottom?

One advantage of this tool that is often overlooked, is its use in washing over pipe that is stuck on bottom. Although the tool was designed primarily for washing over drill collars stuck off bottom in a key seat, we have found that the tool is highly successful in every type of washover operation. Each time a connection is made, during the washover operation, the fish may be pulled on or the jars tripped. This often frees the fish, saving many hours of unnecessary washing over.

What Is the Strength of the Tool?

This tool has a tensile strength of well over a half-million pounds. An example of its ruggedness, on one operation: We have sixteen 6¾" drill collars stuck in a key seat. Oil jars were run above the wash pipe with nine 6¾" drill collars run above the jars. The jars were tripped at 100,000 pounds above the weight of the drill pipe and the fish pulled free.

How Dependable Is This Tool?

At the present time we are unable to give an accurate ratio of successes to failures because the tool has never failed. To date the tool has been run over three hundred times and has never dropped a fish. If there was ever a fool-proof tool made, the Tri-State Washover Drill Collar Spear is it.

This tool has filled a long-standing need in the Oil Industry. We, here at Tri-State, along with the many operators who have used the tool, feel that this Tri-State Washover Drill Collar Spear is the most outstanding oil well fishing tool ever developed in the past twenty years.

So—

Don't Drop That Fish!

Catch it safely with Tri-State's new Washover Drill Collar Spear.

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Corpus Christi, Tex.	Laurel, Miss.	Jackson, Miss.

TRI-STATE OIL TOOL CO. SHREVEPORT

John Payne Heads New Southern API District

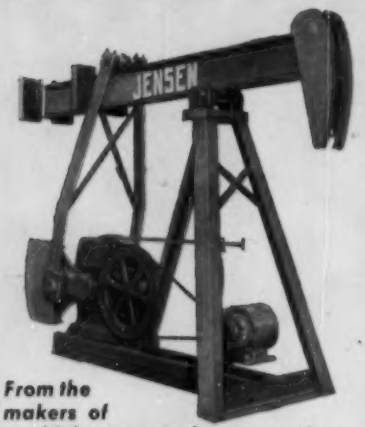
John M. Payne, Shell Oil Company, Houston, Texas, has been named Southern District chairman, American Petroleum Institute, division of production.

The newly-formed section of API elected officers at the close of its first three-day meeting March 7-9 in San Antonio. This new district brings together oilmen from Arkansas, Louisiana, Mississippi, South and East Texas.

Area vice chairmen selected are Mike Dillingham, Alice Drillers, Alice for Southwest Texas; A. T. Miller, Mobar Mud Company, Lake Charles, for Southwest Louisiana; W. E. Richards, Rock Hill Oil Company, San Antonio, for the Balcones Area; B. C. McCree, Union Producing Company, Shreveport, Louisiana, for Ark-La-Tex; J. F. Roth, The Red Supply Company, Houma, for Southern Louisiana; Jim Buckley, Sun Oil Company, McAllen, Texas, for the Rio Grande Valley; Roy A. Bobo, Phillips Petroleum Company, Houston, for the Texas Gulf Coast; Bert Crowder, Humble Oil & Refining Company, Athens, for East Texas; W. D. Taylor, Schlumberger, Victoria, for South Central Texas; and W. N. Bynum, Hycalog, Inc., Shreveport, secretary-treasurer.

Payne served as chairman of the district's first program committee and presided over the general session on March 8.

The new chairman holds a BS in petroleum engineering from the University of Texas. He has worked as an equipment engineer for Black, Sivalls and Bryson in Oklahoma City, and later was employed by the War Department as a petroleum products expediter during World War II. In 1944 he became associated with Shell Oil Company in Houston.



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NEW No. 5 JENSEN JACK
with double and single gear reductions

The NEW No. 5 JENSEN JACK is engineered to lift MORE oil for LESS money from any 1,000 to 1,500-ft. well. It has all the construction features that have made JENSEN JACKS famous throughout the world.

Before you buy any jack, get complete information about the functional design, economy and dependability of the NEW No. 5 JENSEN JACK. See your dealer or write JENSEN BROS. manufacturers of JENSEN JACKS for more than 36 years.

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LED-PLATE ANTI-SEIZE COMPOUND
For Xmas Trees, Valves, Casing, Piping, etc.

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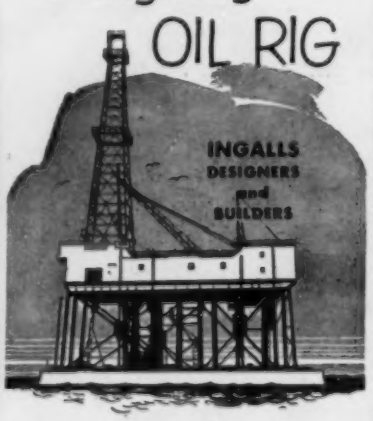

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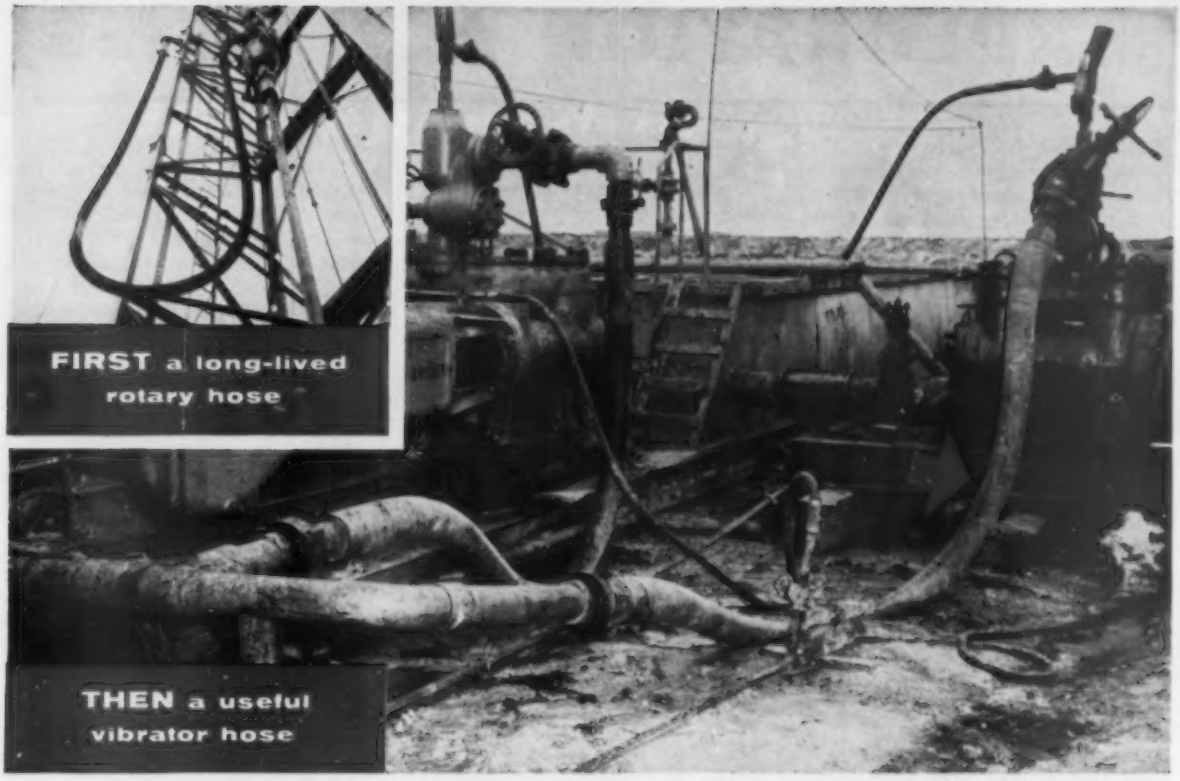

NEOPRENE hose does double duty

. . . cuts replacement costs for driller

NEOPRENE STABILIZERS

last through extra thousands of feet. The Big West Drilling Co., Midland, Texas, reported using only 3 in 13,000 feet of drilling . . . more proof of neoprene's remarkable staying power.

After a long-term stint on a rotary rig, this neoprene hose had plenty of life left . . . and now serves as vibrator hose for the Hinkle Drilling Company, Houston, Texas. Two tours of duty in one rugged product! It's just one more way neoprene gives *extra* service under the most punishing conditions.

Abrasion, weathering and all types of mechanical abuse are taken in stride by neoprene, Du Pont's chemical rubber. You can depend on it to withstand oil, sunlight and heat. That's why neoprene outlasts ordinary resilient materials many times over.

It pays to let neoprene work and save for you. Next time you order rotary hose, vibrator hose, drill-pipe protectors or piston rubbers, specify Du Pont neoprene and be sure of extra-long service life.

FREE! THE NEOPRENE NOTEBOOK. Every issue contains interesting stories, illustrated case histories and new applications of neoprene. To receive it regularly, mail the coupon below.

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EXPLORATION ACTIVITIES

COLORADO

★ Phillips Petroleum Company has a Weber sand oil discovery in Rio Blanco County, nine miles southeast of the Rangely field. The Weber sand is the same formation which is yielding prolific oil production from the Rangley field. The discovery well, No. 1 Douglas "A", which has 78 net feet of pay sand, swabbed and flowed through 2-in. tubing at the rate of 237 bbl of 42.5 deg oil daily after open hole fracturing between 7500-7627 ft. Phillips is commencing a second well one-half mile north of the No. 1 Douglas "A".

UTAH

★ The Texas Company's No. 1 Navajo in San Juan County has been completed with a daily potential of 1704 bbl of 43.3 deg oil. Production is from the Paradox formation at 5828-74 ft. The well was drilled on 5923 ft and plugged back to 5881 ft.

OKLAHOMA

★ Union Oil of California has a pool opener about nine miles north of the recently-opened Gower area in Beaver County. The No. 1 Franz is a gas discovery southeast of the Boyd townsite. The well flowed 7,750,000 cu ft of gas a day, after treating perforation at 7108-20 ft and 7124-30 ft. It was plugged back from a total depth of 7643 ft; 5½-in. casing was set at 7194 ft. During the drilling phase, the Morrow sand was called at 7090 ft and a one-hour drillstem test at 7104-23 ft did an estimated 1,000,000 cu ft of gas per day with a recovery of 100 ft of gas and condensate cut mud.

★ In Woodward County, Magnolia Petroleum is continuing tests on a significant deep wildcat three miles north of Vici. The No. 1-A Borden is running tests through perforations at 13,065-090 ft. Operators cemented 5½-in. casing on bottom at 15,538 ft. During drilling phase, a 50-minute opening at 12,340-390 ft surfaced gas in 40 minutes to make an estimated 1,500,000 cu ft a day, with recovery of 9720 ft of oil and gas-cut salt water. Baker & Taylor Drilling Company has the contract.

★ Western Oil & Gas has found production in the Mississippi lime to open a new oil-gas pool two miles northeast of the abandoned McWillie area and three miles northwest of the Helena townsite, in Alfalfa County. The well is the No. 1 Crissup; exact productive interval has not been announced, although the top of the zone was called at 6175 ft and 5½-in. casing was set on bottom at 6276 ft. Perforations in the lime did 10,000,000 cu ft of gas a day with 10 bbl of oil and no water in one hour. On drillstem test from 6189 ft to bottom, the well tested an estimated 2 to 4,000,000 cu ft of gas a day.

NORTH DAKOTA

★ Sohio Petroleum Company has indicated a new oil discovery three miles northwest of the Bluell field in Renville County. The company's No. 1 Lindemood tested the interval between 4657 and 4668 ft for recovery of 480 ft of free oil and 3727 ft of salt water. The well is about a mile from the Canadian border.

CANADA

★ Southern Production Company and Canadian Atlantic have completed a Cardium sand discovery oil well in the Coalspur area of Alberta, Canada, approximately 110 miles southwest of Edmonton. The well, Southern Production-Canadian Atlantic A2-3, flowed 143 bbl of 44.2 gravity oil per day through a half-inch positive choke on 24-hour production test. Flowing tubing pressure was 75 psi. Basic sediment and water were nil. The test followed fracturing of the well. The well is producing from the Cardium from perforations at 8118 to 8126 ft. The well is approximately a 30-mile west extension of Cardium production in the Pembina field.

Production testing will continue through March 15, at which time all equipment will have to be out of the area because of the thawing of the terrain. The well is located in the muskeg country, where drilling operations are restricted to the winter months. Further testing of the Belly River formation will also be undertaken by the Company next winter at a depth of 5944 ft, where an open hole drillstem test recovered 480 ft of free oil having a gravity of 34 deg.

PAPUA

★ Australasian Petroleum Company and Island Exploration Company have encountered a "substantial gas flow" on a test in this country in East New Guinea. The well, Kuru 1, found gas at 998 ft, with 18⅝-in. casing cemented at 449 ft. The well was spudded January 1. This show is the first concrete result of 20 years of search in the Papuan jungle, say officials of Standard-Vacuum, major owners in the two operating firms. The exploration program has cost about $36,000,000. Ten wells have been drilled to a total of more than 85,000 ft.

TEXAS

★ A new field in Marion County, East Texas, has been opened by Carter-Jones Drilling Company No. 1 Whelen. The discovery is about 2 miles northwest of the Wallace-Johnson field, which produces from the Young section of the Rodessa. The new wildcat was drilled to 6986 ft and casing was perforated at 6065-72 ft in the Sand Hill section of the Rodessa. The well flowed 327 bbl of oil per day on a ¼-in. choke with gas-oil ration of 500 to 1.

★ Cities Service, Lone Star Production, and Signal Oil & Gas are locating wo test wells on the 38,000 acre Swenon Flat Top Ranch in Stonewall County, the first of which is spotted in the northwest corner of the ranch, nine miles southeast of Aspermont. The initial test, the Flat Top 165 No. 1, is to be drilled to 4200 ft with the Canyon formation as objective. Nearest production is in the prolific Flowers Canyon Pool one mile to the northwest. The second test, the Flat Top 162 No. 1, will be three miles southeast of the Flat Top 165 No. 1. Total depth has been set at 4300 ft and the objective formation is the Canyon.

★ Lion Oil Company (Monsanto) and D. D. Feldman Oil & Gas has completed the Manor No. 1 as a confirmation well on a large block in Brazoria County, Texas.

The new well tested 46 bbl of condensate and 4,506,000 cu ft of gas per day through a 15/64-in. choke with 3246 psi tubing pressure. Perforations extend from 9966 to 9970 ft in the Frio sand. An aggregate of approximately 200 ft of gas sand was encountered in drilling the well. Total depth is 10,898 ft. The new well encountered the same sands found in the discovery well, the Tri No. 1. The Manor, however, was drilled to deeper formations and is producing from a zone 400 ft below that of the earlier well.

CALIFORNIA

★ Union Oil Company has confirmed its Costa sand discovery in the Oil Creek area of San Mateo county, where its wildcat made the first commercial discovery of high gravity oil in that section last November. Union's Costa 2 was reported today to be producing at the rate of approximately 30 bbl a day of 42.2-deg crude oil and 500,000 cu ft of gas from the interval 1915 to 2000 ft. A third directed-hole well is being drilled 660 feet to the northwest.

it happened in 1939

Recently one of our clients remarked, "I had Core Lab work a well for me back in 1939 . . . and just the other day I needed a copy of that old report. Sure enough, your home office was able to furnish it. That kind of service makes a difference!"

Thank you, "John Doe," for the expression of confidence. Perhaps, because Core Lab often handles that type of request, we take *stability* for granted. We have never doubted our future but, now that you've mentioned it, the word seems pretty significant. What could be more important to an organization pledged to develop, interpret, and assume responsibility for confidential reservoir information?

How do you earn this stature? In Core Lab's case, it is the reward of twenty years' experience gained through the analysis of nearly 1,000,000 feet of reservoir rock and continued investment in the search for better techniques and procedures. Add the priceless factor — *integrity* — and you have reached the plateau of unquestionable stability.

In this role of leadership, Core Lab adds another job every forty minutes of every working day.

THE ONLY FULLY INTEGRATED PETROLEUM RESERVOIR ENGINEERING FIRM

CORE LABORATORIES, INC.
801 CORE STREET, DALLAS, TEXAS

CORE LAB
PETROLEUM RESERVOIR ENGINEERING

DALLAS, HOUSTON, CORPUS CHRISTI, MIDLAND, ABILENE, SAN ANTONIO, TYLER, LIBERAL, FT. WORTH, WICHITA FALLS, KIMBALL, OKLA. CITY, TULSA, ARDMORE, BARTLESVILLE, PAMPA, ARK. CITY, GT. BEND, NEW ORLEANS, SHREVEPORT, HATTIESBURG, LAFAYETTE, DENVER, BAKERSFIELD, CASPER, BILLINGS, WORLAND, STERLING, EL DORADO, LUBBOCK, FARMINGTON, LOVINGTON, MONAHANS, SAN ANGELO, CALGARY, EDMONTON, REGINA; VENEZUELA, S. A.

Do You have a "Frac" Well that's tough to Pump?

THEN you should try a Pacific "OIL STATES" rod insert, bottom hole oil well pump...

WHY? because the "OIL STATES" is pumping some of the toughest, sandfrac wells in the Mid-Continent fields—from the extreme depths in West Texas and the gulf coast to the shallower zones in Oklahoma, Kansas and Illinois...

In well after well, oil operators report highly successful pumping with Pacific "Oil States," particularly after trying cup and ring pumps or metal-to-metal pumps with wide tolerances between plungers and tubes. The Pacific "Oil States" offers a new approach to pumping sandy or dirty oil wells. Specifically manufactured to a very close tolerance between plunger and liners, so as to eliminate sand passing between the sealing surfaces which normally cut and score plunger and liners. The Pacific "Oil States" is not merely a "clean-out" pump. It is engineered to pump sand with its "surging action" and further, to pump with a high efficiency made possible only by the close tolerance.

Check these features:

- Furnished with a tolerance between plunger and liners in fits as close as Minus ½ thousandth...
- Furnished in standard steel with stress-proof, heat treated fittings for normal sandy pumping...
- Furnished with stainless steel barrel and parts with "PACILITE" Hard Chrome Plunger for corrosive conditions...
- Furnished in "Stroke-Thru" design to eliminate sticking of plunger and liners in wells that deposit gyp or barium.
- Furnished in pump lengths from 4 feet to 20 feet, with a wide choice of arrangements of valves and fittings...
- Furnished in the following sizes and bores:
  1" and 1¼" for 2" tubing
  1½" and 1¾" for 2½" tubing
  2¼" for 3" tubing
- Plunger and Liners can be "Reground" several times to give the most economical repair costs...

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PACIFIC

DW-15

Exploration

NEW MEXICO

★ Cabot Carbon Company's No. 1 Fleet, a multipay prospect in Lea County, is continuing tests. A favorable drillstem test was taken at 12,586-676 ft with a recovery of 180 ft of oil, 270 ft of oil and gas-cut mud and 1440 ft of water blanket. The wildcat is about a mile from the one-well King (Wolfcamp) pool. The Fleet flowed oil from the Devonian at 12,380-502 ft and recovered oil on Devonian tests at 12,313-80 and 12,532 ft after indicating Wolfcamp, Pennsylvania and Mississippian production.

★ A new oil discovery four miles southeast of the Four Corners area has been indicated by Humble Oil Company. Some reports suggest that it is the biggest strike in northwestern part of the state since the discovery of the South Blanco Tocito pool in 1951. On a 2½-hour test the well flowed at a rate of 20 bbl an hour from the Hermosa (Pennsylvanian) formation.

CUBA

★ An exploratory well is being drilled in Northwest Camaguey Province by Atlantic Refining Company in cooperation with Dr. Antonio Iglesias, discoverer of the Jatibonico field. This is Atlantic's first drilling activity in that country since 1946. In this new venture in Camaguey Atlantic holds substantial acreage in the general area surrounding the new drilling location.

KANSAS

★ Cities Service's wholly owned Depenbusch No. 1 is being located as an Arbuckle test in Kingman County. The test is located 15 miles southwest of Kingman, and 1¾ miles south of the nearest production. Scheduled to drill to 4900 ft, the well will test the Lansing-Kansas City, Mississippian, Viola, Simpson and Arbuckle limestones, sandstones and dolomites.

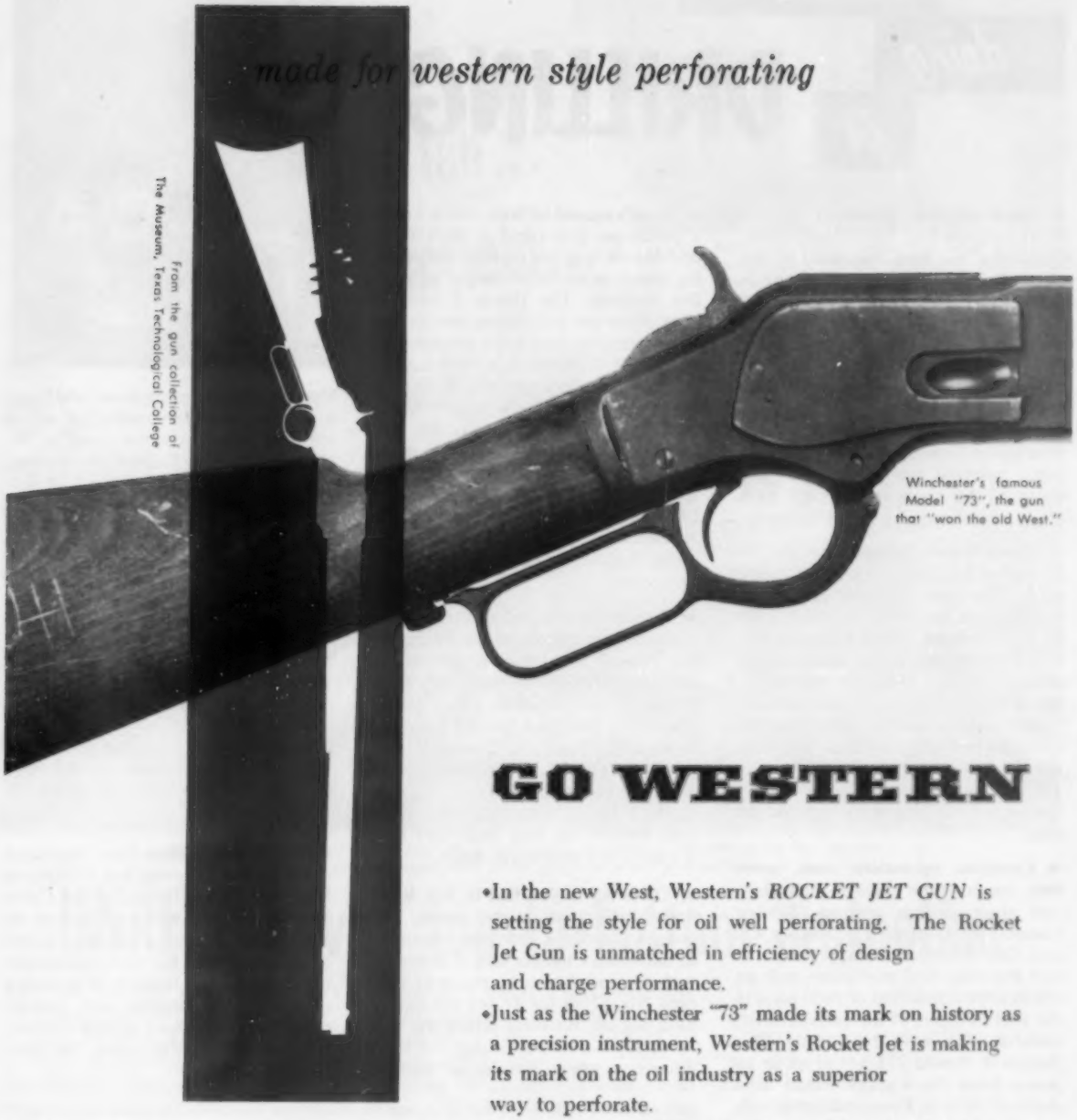
LOUISIANA

★ Cities Service announced today that its State Lease 2709 No. 1 is being located as a test well approximately 30 miles south of New Orleans.

The test will be drilled on a 3520 acre unit in LaFourche Parish. Objective of the 17,000 ft well will be Miocene sands. Nearest production is approximately four miles to the northwest.

★ Sunray Mid-Continent Oil Company has opened a new gas-condensate pay area six miles north of the North Starks area in Beauregard Parish. The No. 1 Lutcher-Moore Lumber Company gaged 1,200,000 cu ft of gas and 72 bbl of condensate per day through an 8/64-in. choke flowing from perforations at 8594-614 ft.

made for western style perforating



From the gun collection of The Museum, Texas Technological College

Winchester's famous Model "73", the gun that "won the old West."

GO WESTERN

- In the new West, Western's *ROCKET JET GUN* is setting the style for oil well perforating. The Rocket Jet Gun is unmatched in efficiency of design and charge performance.
- Just as the Winchester "73" made its mark on history as a precision instrument, Western's Rocket Jet is making its mark on the oil industry as a superior way to perforate.
- There's no extra charge for the premium perforating of Western's Rocket Jet Gun . . . . you get greater entry hole size and greater penetration.

Next time, *GO WESTERN!*

WESTERN Engineered WELL SERVICES

THE WESTERN COMPANY

engineered well services

general offices: Midland, Texas

Texas: Odessa, Seagraves, Levelland, Snyder, Lubbock, Borger / **Oklahoma:** Lindsay, Healdton, Okla. City / **New Mexico:** Hobbs / **Kansas:** Ulysses, Liberal

What's doing in DRILLING

★ **One-hundredth producer** in the Short Junction field, Cleveland County, Oklahoma, has been completed by Big Chief Drilling Company. The well is Continental Oil Company's No. 1 Cecilia Straka. The well was finaled in the Bois d'Arc with perforations at 7974-94 ft, 8000-12 ft and 8020-35 ft. After 500 gal of mud-cut acid wash, the well flowed 36 bbl of load oil, 100 bbl of acid water, and 20 bbl of new oil in 90 minutes through a ¾-in. choke. On initial potential test the well did 232 bbl of 37-deg crude and 189,000 cu ft of gas a day through a 12/64-in. choke.

★ **Three North Dakota wildcats** will be drilled by Cardinal Drilling Company. The trio, located in Foster County, will be carried to about 3500 ft, with support given by Pure Oil, Mobil Producing, and Continental Oil companies. The wells are the No. 1 James Smith, about three miles east of a 3600-ft duster near Carrington; the No. 1 Graves-Federal Land Bank, five miles northeast of Carrington, and the No. 1 J. M. Anderson, four miles west of Carrington, in the central part of the state.

★ **Canadian operations must move fast,** due to some efficient methods—and short drilling seasons. Sinclair Canada Oil Company, a Sinclair Oil and Gas subsidiary, has reported its first Pembina field production only six weeks after acquisition of 1600 acres in the southern part of the current development. The well, No. 16-24 Blue Rapids B, flowed 271 bbl of oil in 16 hours from the Cardium sand at a depth of 5476 ft. Four additional wells are already underway on the tracts.

★ **Six days on — two off** work plan has been adopted by Choya Drilling Company, which operates four rotaries in the Midland, Texas, area. Although this plan has been used in some sections of the country, most operators who have tried the schedule in this area have returned to the seven day week. Choya feels that the plan has created more efficient operations, although the hourly rate is higher than average. Employees average 42 hours a week, with floormen getting $2.24; derrickmen and motormen $2.40, and drillers, $3.24.

★ **Israel's second oil well,** which found a promising pay zone at 4920 ft in mid-March, was last reported still drilling ahead in search of deeper productive horizons. The Heletz 3 made a good show on a drillstem test in the same formation now being produced at the Heletz 1. Heletz 2, a 1400 ft step-out from the discovery well is drilling below 4930 ft. Israel's field is seven miles southeast of Ashkelon on the Mediterranean Sea and just eight miles north of the disputed Gaza strip. The wells in this area are being drilled for Lapidoth-Israel Oil Company by the Matsda Company, an Israeli concern using American superintendents and toolpushers.

★ **Turkey** has awarded several new exploration concessions in the southeastern part of that country. Companies granted licenses include the Bolsa Chica Oil Corporation, Royal Dutch Shell, Esso Standard, Socony Vacuum, Tidewater, Husky Oil Company, and American Overseas Petroleum (Standard of Califoria and Texaco). Most of the acreage taken has been in the area west of the Iraq fields and near Turkey's two productive fields.

★ **Oil is where you find it.** Ask Richfield Oil Corporation this month. The company made a new pool discovery in the South Cuyama field (California) with the completion on pump of Hibberd No. 57-36 for 81 bbl per day of 28.2 deg oil. Richfield drilled the well as an input well but salvaged it for a discovery when unexpected faulting made it impossible to use for injection. Total depth is 4359 ft, although the well was completed in the Bittercreek at about 2728 ft. This formation occurs just below the Santa Margarita sand, which gave Cuyama its first commercial well eight years ago at Russell Ranch.

Shell's newest permanent platform, is now on location in 48 ft of water some 45 miles from the coast of St. Mary Parish in the Eugene Island area, Louisiana, in field 128, block 116. Six wells can be drilled from one derrick position and then shifted to drill six more. All this is done by shifting the crown block inside the enlarged water table.

★ **Cable tool drillers** have organized in Oklahoma. A group met in Tulsa in March to draw up plans for the Cable Tool Operators Association and set up a committee to draft a charter. George F. Martin, Tulsa, has been named acting chairman and James S. Wise, acting secretary. Membership will include cable tool contractors, service contractors and operators who own their own rigs and units.

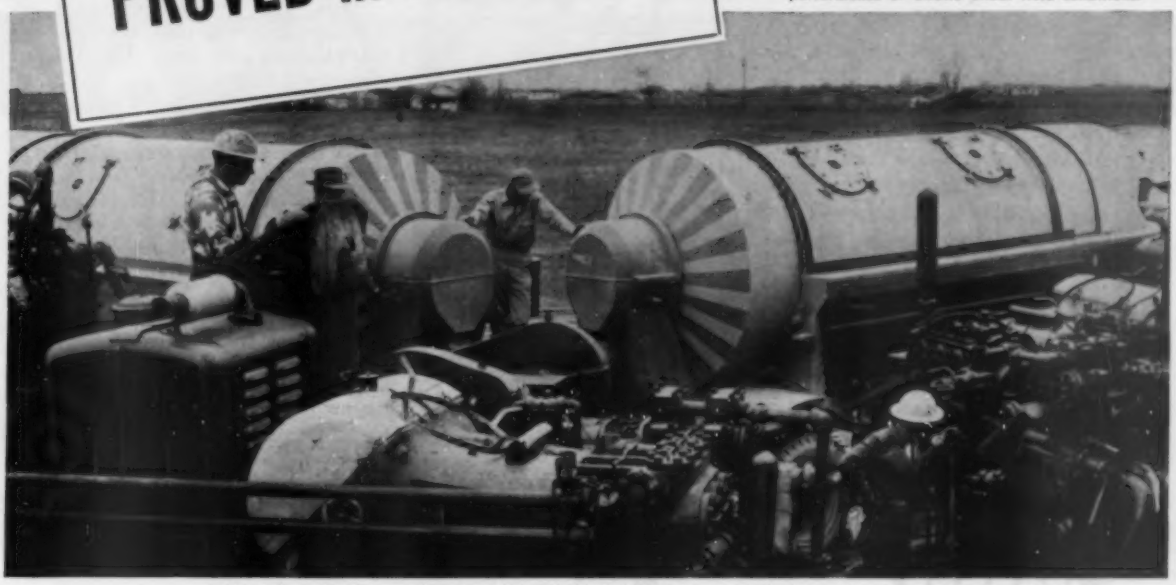
Rotary Rigs Operating in Oil Fields of United States and Canada*

	Feb. 20	Feb. 27	March 5	March 12
Pacific Coast	123	131	133	129
Oklahoma	305	313	302	311
Kansas	176	173	177	183
Rocky Mountains	188	185	195	193
Canada	231	226	226	244
Ark-La-Tex	153	148	156	156
West Texas & New Mexico	509	523	545	552
Gulf Coast	645	644	650	623
Illinois	70	76	87	101
North Texas	365	380	385	380
	2765	2799	2856	2872

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

TESTED in the lab... PROVED in the field...

Here rigid quality control is enforced during the manufacture of Unaflo Oil-Well Cement. Skilled technicians make regular tests to assure uniform performance of Unaflo under field conditions.



Oilmen know Unaflo's quality pays off in reliable field performance. Whether you're on a routine job, or a tough one, you can depend upon Unaflo to give uniformly good performance—every time!

UNAFLO* gives top-to-bottom protection

Start out with the *right* oil-well cement, and you may save money later on. For, when the heat and pressure are high, slurries must go in place trouble-free. That's when Unaflo's advantages show up.

Unaflo slurries pump easily from the start, stay fluid under critical conditions, give you extra time when emergencies arise. Then, after the carefully calculated retarded period, Unaflo gives a strong, tight seal, resistant to sulfate waters.

Follow the example of oilmen who *know* – specify Unaflo, because it's tested in the laboratory and during manufacture to ensure consistent high quality. Unaflo complies with API STD 10A Specifications for oil-well cement, regular type classes D and E. Typical data tables on Unaflo's down-the-well performance and the facts on our other cements are available on request.

*"UNAFLO" is the registered trade-mark of the retarded oil-well cement manufactured by Universal Atlas Cement Company

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Resistant to Sulfate Waters

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UNITED STATES STEEL HOUR—Televised alternate Wednesdays—See your newspaper for time and station.

PE-U-141

Geological Wildcatting Underway on Malta

Geological wildcatting is underway on the island of Malta, in the Mediterranean. A subsidiary of the British Petroleum Company, the D'Arcy Exploration Company has carried out geophysical surveys over both Malta and the even smaller neighboring island of Gozo, and three sites for drilling information holes on Malta have been selected.

Drilling has begun at site No. 1 near Zabbar, situated about three miles inland from the capital city of Valetta. A truck mounted portable drilling rig is being used. The rig is staffed by a drilling supervisor and three drillers sent from England. They are augmented by three assistant drillers, six laborers, and three drivers, all recruited locally.

A palaeontological laboratory has been established at Valetta under the supervision of a resident geologist. The laboratory staff, all locally recruited, is comprised of two laboratory assistants under training, a driver and a messenger.

English crews man this portable drilling of the D'Arcy Exploration Company on the island of Malta. This is the first of three exploratory tests scheduled on the island.

★ **A new offshore drilling rig** has been placed on order by the C. G. Glasscock Drilling Company. Price tag on the new unit is $6,750,00. Designed to operate in 140 ft of water, it will be delivered early in 1957.

★ **First tidelands derrick** in Redondo Beach, California, is now being soundproofed for immediate use by the Santa Fe Drilling Company. The rig will be located at 405 Strand Street. Redondo Beach voters approved the drilling in a special election November 15, 1955.

★ **Ambitious drilling schedule** has been set this year by Petroleos Mexicanos, the government-owned oil monopoly. Pemex plans to drill about 750 wells in 1956, more than twice the number drilled last year.

☆ **Several rigs will be Honduras bound** very soon, to explore some 50,000,000 acres for Houston oilman John W. Mecom and Associates. Mecom has purchased the leases, mostly underwater, from Compania Hondurena. Sellers of the acreage include Honduras business men and a group of Texas operators headed by David C. McCord of Dallas. Hondurena is now drilling a test in the Mosquota area projecting to 4500 ft. The wildcat was last reported below 1795 ft.

Your production man can throw away his bicycle and do a better job from a rocking chair. He no longer has to run all over the field twisting valves.

An entire lease is controlled accurately and precisely in a matter of minutes, right from the old rocking chair, through a battery of Willis Rotary Adjustable Chokes.

6 WAYS BETTER FLOW CONTROL

WILLIS Rotary Adjustable Choke provides 6 different sized choke inserts which are individually positioned in the line of flow by a fractional turn of the orifice-carrying disc . . . while under constant flow and high pressure. The 6 graduated orifices are changed to a new range of sizes in minutes . . . without shutting-in the well.

WILLIS OIL TOOL COMPANY

3440 Pine Ave., Long Beach 7, California
Houston: 2012 Taft Street
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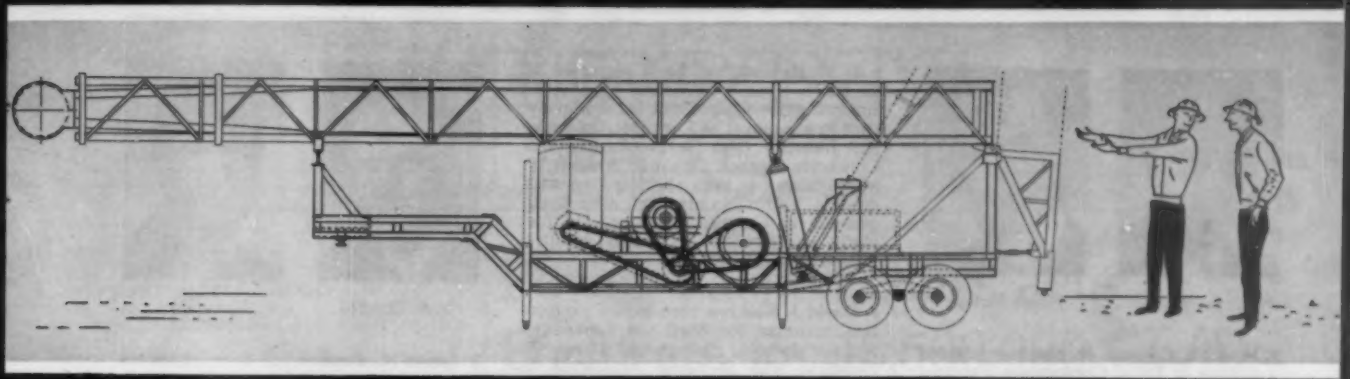
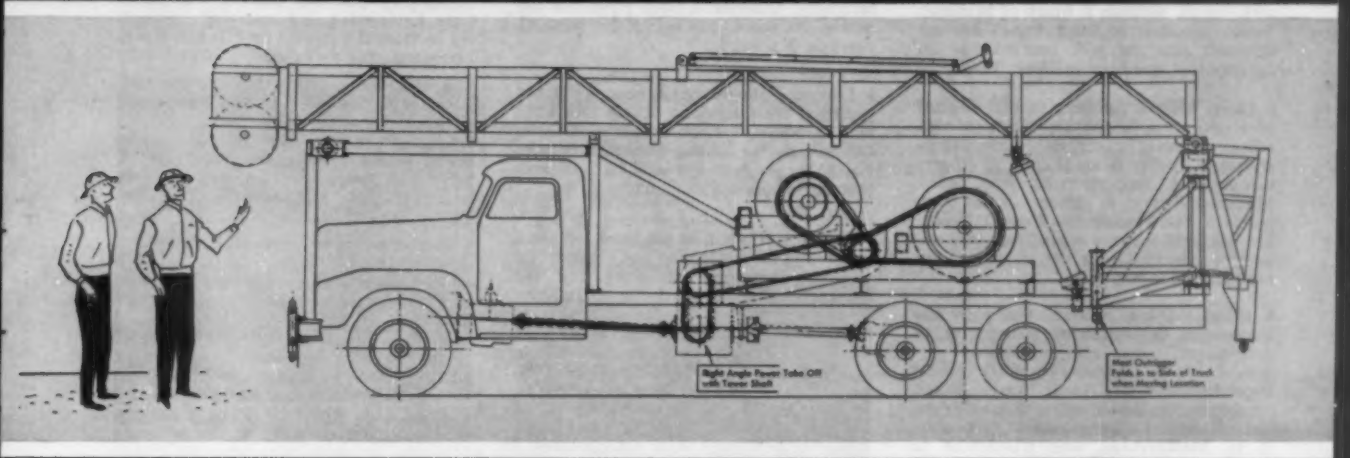
Pick the Winch Drive System You Want



WILSON MANUFACTURES BOTH



Wilson built winches on trucks, with power-take-offs, of Wilson make as early as 1928, and several thousand of these were made, but these were discontinued just before the war because most customers preferred the separate engine.

Recent state restrictions on weight and size have forced well servicing contractors and other users to ask for a "good power-take-off" that will "stand the gaff" of rugged oil field service with a very minimum of "down time" and maintenance cost. We have now designed, field tested and proved what our customers have told us is "*the best heavy-duty truck power-take-off ever built.*" It incorporates many new features never before available in any power-take-off and is built so that is can be used in any make or size of heavy truck.

For the first time users can now obtain a *Modern* High Capacity Mast, with a *Modern* Heavy Duty Air Tube Clutch Drum Winch, with High and Low Clutch drum speeds, and new lightweight clutches which never need adjustment; with this truly *Modern* "1954 Model" Power-Take-Off! And these new units are legal as regards to length, width and height, and *weight distribution!* The Super 38 Double drum units with tubular masts and the usual amount of lines and tools can be made legal in most states. Fabricated Masts on *double drum* units with lines and tools may require permits.

BE MODERN — BUY WILSON

The Lightest, Strongest, Best!

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The FIRST NAME in OIL FIELD WINCHES

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The HOME of RED IRON • WICHITA FALLS, TEXAS

RUNNING TOUR with MEN in the INDUSTRY

F. W. Fairman, Jr.

Pierre Maugis

Fred W. Fairman Jr. has been elected a director of Tekoil Corporation. Fairman is chairman of the board of Fairman, Harris & Company, Inc., investment bankers, Chicago, Illinois, and a former director of The Saint Anne's Oil Production Company, which recently merged with Tekoil. **William J. Finch** of Midland, Texas, president of Saint Anne's has announced that he will continue as an independent operator in West Texas.

Pierre Maugis has been named director of Exploration Geophysique Rogers with offices in Paris, France. Exploration Geophysique Rogers is an affiliate of Rogers Geophysical Company of Houston, Texas. Maugis will serve as director of this company in France and the French Union. He has held various engineering and executive positions with the oil companies and petroleum societies.

Humble Oil & Refining Company has announced the following changes in its production department supervisory personnel. **W. W. Thames,** formerly district superintendent at North Katy, Texas, transferred to the Anahuac district as assistant district superintendent, replacing **J. H. McReynolds,** who transferred to the Goose Creek, Texas, district as assistant district superintendent. **W. L. Hooks,** formerly district superintendent at Livingston, Texas, moved to the Hardin, Texas, district as assistant district superintendent.

R. H. Suman, district petroleum engineer at North Katy, transferred to Maurbro district as district petroleum engineer. **P. L. McGee,** district petroleum engineer at Livingston, transferred to Raccoon Bend district in the same capacity.

O. O. (Lee) Furse, assistant division superintendent, East Texas division, transferred on a temporary basis to the purchasing department, Houston, Texas, office, as assistant purchasing agent. **J. M. (Jack) Rives,** returned to his regular job in the Southwest Texas division as safety engineer following a six-month assignment in the safety division, Houston. **T. H. Simons,** formerly a safety engineer in the Southwest Texas division, was promoted to assistant regional employee relations manager, North Texas division.

Charles A. Blanchard has been promoted to administrative assistant to the division superintendent of the Gulf Coast division of Rowan Drilling Company, Inc. He has been with Rowan at New Orleans, Louisiana, since 1952. **Clyde D. McHam** has been advanced to administrative assistant to the division superintendent of Rowan's West Texas-New Mexico division. McHam has been employed since 1948 as a division clerk at Midland, Texas.

J. P. Badami has been promoted to the newly created position of geophysical supervisor for Continental Oil Company, with headquarters at Durango, Colorado. He formerly was a geophysicist for Conoco in Denver, Colorado. **Francis W. McWilliams** has been appointed assistant division land superintendent, with headquarters at Casper, Wyoming. He formerly was assistant division land superintendent in Denver.

David J. Kull has been named exploration manager for Shell Oil Company's Kansas division, succeeding **Alfred N. Sharrick,** who is being transferred to Midland, Texas. In 1954, Kull was promoted to exploration manager of the company's Colorado division, and in June of last year he was given a special foreign assignment, from which he is now returning. Sharrick, a Shell employee for nearly 20 years, has spent the past 15 years in Kansas.

Lorence Falkenberg has been appointed geologist for Canadian Bishop Oil, Ltd., with headquarters in Calgary, Alberta, Canada. Before joining Canadian Bishop, Falkenberg was on the staff of California Standard Company of Canada.

David A. Carnahan has been elected a vice president of Drilling and Exploration Company, Inc. He will be primarily concerned with foreign operations and will headquarter in Los Angeles, California. Carnahan formerly was chief engineer and then sales manager for a manufacturer of oil field equipment. He previously held the position of chief engineer at Drilexco.

D. A. Carnahan

John H. Douma has been named manager of joint operations, and **M. S. (Steve) Patton Jr.** has been named manager of engineering for Sunray Mid-Continent Oil Company's production department. Other promotions include the naming of **Frank C. Folger Jr.** as assistant manager of engineering and the promotion of **M. Buford Penn** to chief unitization engineer in the joint operations division. All are longtime employees of the company's production department. **Karl Martin** has been named division landman for Sunray Mid-Continent in charge of the Wichita, Kansas, Denver, Colorado, and Casper, Wyoming, districts. Martin previously was district landman in the Corpus Christi, Texas, district and has been with the company since 1948.

Dr. F. G. Baptista of Coro, Venezuela, has been named assistant manager, production department, for Creole Petroleum Corporation at Caracas, Venezuela. **F. K. Davis** has been appointed superintendent of the Caripito district, eastern Venezuela, succeeding **M. G. Ball. D. C. Meyer** of New Orleans, Louisiana, has replaced **G. C. Holcomb** as assistant manager, geological department, at Caracas.

J. A. Cusator

L. A. Gray

James A. Cusator has been appointed as district manager of the Shreveport, Louisiana, district of Core Laboratories, Inc. Until recently, Cusator served as assistant district engineer for Core Lab's entire ten-state Rocky Mountain region. In his new position, Cusator will direct Core Lab's integrated reservoir engineering services throughout East Texas, North Louisiana, and Arkansas.

Lewis A. "Bullet" Gray has been made technical sales representative for Crossett Chemical Company. For the last several years, he has been an engineer for two large mud companies. Gray will make his headquarters in Wichita Falls, Texas.

R. G. Perry will be manager of exploration for D. D. Feldman Oil & Gas in a multi-million dollar expansion program that will spread over the whole of western Canada.

Perry, a veteran of more than 30 years in the petroleum industry, has spent the past 8 years in Canada. Perry comes to the Feldman organization from Peel Plateau, Ltd., where he held the position of exploration manager in charge of an extensive geological program in the Yukon and Northwest Territories extending from the Alaskan border to the Mackenzie River.

Dr. Harry H. Power, chairman of the department of petroleum at the University of Texas, has received the first Fulbright Award to be granted in petroleum engineering. While on a current trip to Europe, he will present various courses in petroleum engineering and related subjects at the University of Delft, the Netherlands. His plans also include giving lectures before various scientific and technical associations in West Germany, France and Great Britain.

Samuel H. Woods has retired as division chief geologist of Sun Oil Company's Mid-Continent division, Tulsa, Oklahoma, after 34 years of service with Sun. **Ronald J. Cullen,** another veteran Sun man, succeeds him.

Woods joined Twin State Oil Company, which later became Sun's Mid-Continent division, in 1922. He received his BA in geology from the University of Oklahoma. Woods helped organize and is a charter member of Sigma Gamma Epsilon, honorary geological fraternity of oil.

Cullen also joine the Mid-Continent Division when it was the Twin State Oil in 1927. He was made assistant division chief geologist in 1954. Cullen was graduated with a BA in geology from the University of Oklahoma.

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50
Locations in the United States and Canada

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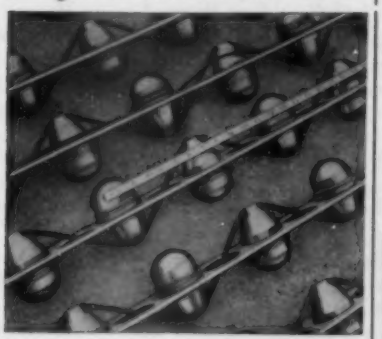
Service
Anywhere Anytime

New Services • • • New Tools • • • New Methods • • • Outstanding Results

Super Casing Glass Jets Shoot 320 Holes in One Run

A McCullough Super Casing Glass Jet Perforator with Steel Strip Carrier was used to perforate an 80′ pay zone at approximately 9300 feet.

Only one run in the hole was required to shoot the 320 Glass Jets, four holes per foot, through 5½″ O.D. 17 lb. N-80 casing cemented in 9″ hole.



Sections of McCullough Glass Jet Perforators and Steel Strip Carriers. After perforator is fired, the Steel Strip Carrier is removed from the well intact.

After perforating, the well came in for 210 barrels of oil and 2⅛ million cubic feet of gas per day.

Only two hours were required to complete this job, including rigging up and tearing down time.

Their ability to perforate pay zones of nearly any thickness or multiple zones in a single run in the hole, makes McCullough Glass Jet Perforators with Steel Strip Carriers of particular value to the operator.

Carriers may be loaded full length or sections may be left blank to leave unperforated areas in the casing. Steel Strip Carriers in excess of 100 feet in length have been run with complete satisfaction.

Result: Less rig time; greater efficiency; more economy.

Power Packed Glass Jets Perforate for 15,500,000 CF/D

McCullough Standard Casing Glass Jets Shoot 336 Holes in 4½″ O. D. Drill Pipe Liner at 15,000′

Deep penetrating McCullough Standard Casing Glass Jets turned in a highly successful, time-saving performance in a deep New Mexico gas well, according to a recent field report.

After drilling to a total depth of 15,120 feet, 3,010 feet of 4½″ O.D. drill pipe was set as a liner. The hole was full of 13 lb. mud and hydrostatic pressure at the perforating depth was 10,200 lbs.

Two runs were made with 2¾″ Standard Casing Glass Jets in Steel Strip Carriers; one 45 feet in length, the other 39 feet. Tapered weights were run on the bottom of the Steel Strip Carriers to enable them to enter the top of the drill pipe liner at 12,062 feet.

McCullough Glass Jets are the best jet perforating process available. They have more power; penetrate deeper through multiple strings of casing and extra thick cement sheaths into hard and extra hard formations. Holes are larger, more uniformly round and are straight sided almost the entire depth of penetration. This means more exposed formation area, greater production, more oil!

336 Standard Casing Glass Jets, four per foot, were fired in 84 feet of zone between 14,942 and 15,026 feet.

On test, the well produced 15,500,000 cubic feet of natural gas per day—a new gas field discovery.

Several factors contributed to the operators full satisfaction with this job. First, the use of 2¾″ Glass Jets in Steel Strip Carriers made it possible to run inside the restricted I.D. of the 4½″ drill pipe liner and gain effective penetration through the thick walled pipe with the full power of the Standard Casing Glass Jets. McCullough Glass Jet Perforators use a more powerful shaped charge in relation to their outside diameters than any other jet perforators available.

Second, the entire job including rigging up, two round trips to 15,000 feet and tearing down, took only five hours rig time—an important saving in costs.

Third, as usual both Steel Strip Carriers with weights were removed from the well intact and no junk was left at the bottom of the hole to complicate future operations.

McCullough® TOOL COMPANY

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HOUSTON
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Safety CASING HANGERS

1. SIMPLIFIED, STREAMLINED DESIGN. NO DRAG SPRINGS. FEW PARTS PROMOTES GREATER STRENGTH AND EFFICIENCY.
2. LEAD SEAL BELOW SLIPS WILL NOT SET GOING IN HOLE. WON'T BULLDOG ON RETRIEVING.

Years ago we set out to cut the high costs of oil well drilling, not just in theory but in practice; not just in pennies but in thousands of dollars. The wasteful overlapping of casing and how to eliminate it took our eye so we set out to whip it. RESULT: Today you find Burns Casing Hangers all over the world saving millions of dollars in casing cost and make-up time.

With the Burns Hanger you suspend the casing in tension—casing won't sink in the formation, buckle or bend into cavities. Slips bite sharply into the casing at the setting depth and stay there—100% full bearing slips instead of the old 2 point cone type prevents slip breakage. Lead seal below the slips won't set going in the hole—won't jam the slips upon retrieving. Weight of the oil string compresses the lead seal on setting, forming a perfect and permanent lock to the casing—no safer method has ever been devised.

Thousands of Burns Hangers are now in use in every field, at every depth; by independents and majors alike. We're extremely proud of the Burns line of hangers and only now after years of successful field experience are we beginning to broadcast this story through world-wide media.

Burns Hangers are available in all popular sizes. Prices upon request. Please give size, weight and the thread connection of oil string, and also size and weight of casing in which you set hanger. Check with us direct or consult a Burns Distributor.

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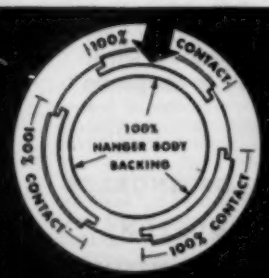
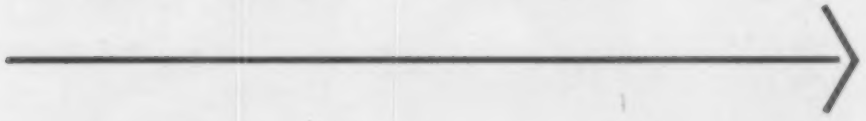


LOOK BEHIND THE SLIPS

Specialized Construction provides each slip with 100% hanger body support throughout the entire length of slip travel—no cracked or broken slips—positive operation—all the area of each slip securely grips the casing.

1. BURNS LEAD SEAL CASING HANGER *with hold down slips. Slips set automatically after casing is suspended.*
2. BURNS CIRCULATING TYPE CASING HANGER *with lead seal pack off. On cementing jobs this hanger assures easier circulation around the hanger and a positive seal after cementing.*
3. BURNS DELAYED ACTION LEAD SEAL PACK OFF CASING HANGER. *Same features as the Burns circulating type except the by-pass ports are eliminated. You can hang your oil string, circulate, and cement before closing the lead seal packing element.*

Turn This Page
to see the
Greatest Improvement
in Slush Pump
Valve Design
in 25 Years



.....THIS NEW KIND OF.....

.....SEALING RING MAKES.....

.....MISSION.....

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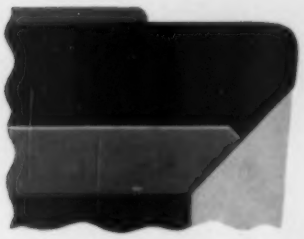
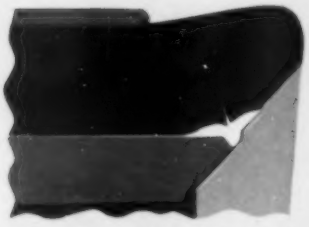
.....VALVES.....

LAST LONGER

CONVENTIONAL



Conventional valves use a sealing element that seals at an angle, usually in the same plane with at least part of the striking surface. This arrangement works well when the valve is new and when pump pressures are low.



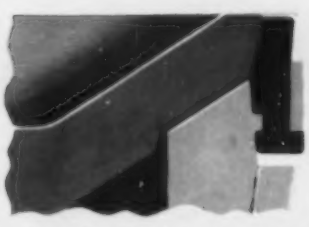
With wear, however, an opening forms at the junction of valve body, seat and sealing element. High pump pressures force part of the rubber sealing element into this space and it is pinched off. The result is short life for both sealing element and valve.

MISSION MUD MONARCH

NEW

With Mud Monarch Valves, the valve body strikes against the entire inclined surface of the valve seat, and the near-vertical seal ring seals against the outside diameter of the valve body. With this design, seal ring life is independent of valve and seat wear.

OLD



With wear, the entire inclined striking surface of the seat is worn away. An opening can't form next to the seal ring. Both valve and seat wear longer before they need be replaced and seal ring life is increased substantially—

HERE'S WHY MUD MONARCH VALVES LAST LONGER THAN CONVENTIONAL VALVES UNDER JET DRILLING CONDITIONS

Most slush pump valves do a good job when they are new, but when valve body and seat become worn, an opening forms between seat and body next to the sealing element that plays havoc with valve life. This condition exists, to a certain degree, with all valves except the Mud Monarch. By preventing the formation of this opening, Mission Engineers have developed a valve that gives truly outstanding service – especially in high pressure jet drilling where most valves fail rapidly. If you are dissatisfied with the service you are getting from slush pump valves, try the Mission Mud Monarch. You will discover a new high in valve performance and a new low in valve costs. Like all Mission Products, Mud Monarch valves are guaranteed to give outstanding service or your money is refunded. You can't lose, so try them right away. They are made in sizes to fit most pumps and are available through all supply stores.

Mission Mud Monarch Valve

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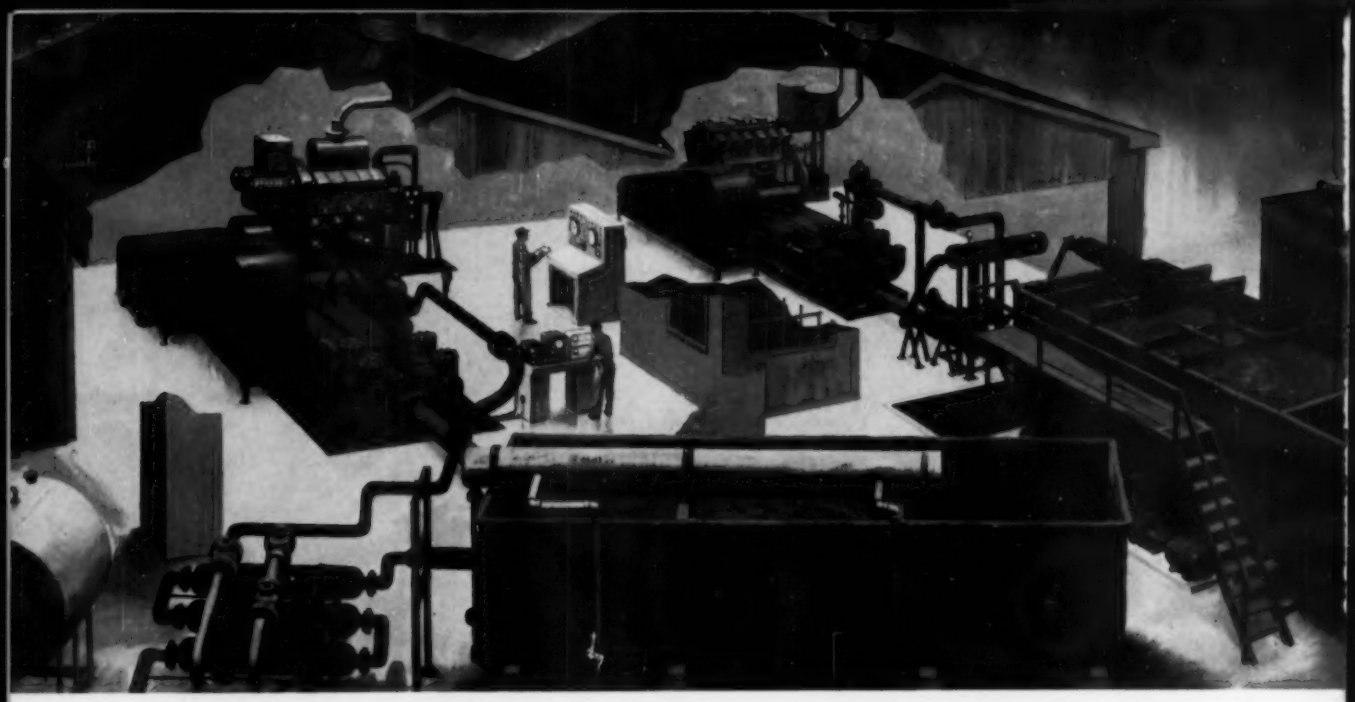

Only Mission has a fully instrumented test pump "laboratory" like this...

No other pump parts manufacturer has such an advanced setup. These test pumps at the Mission main plant are fitted with the latest in electronic test instruments including a fourteen channel recording oscillograph. This instrument is, to the Mission Research Engineer, what an electrocardiograph is to a doctor! Here, Mission research men conduct tests using a variety of contaminated or sand laden muds at temperatures that average 155°F and pressures that often exceed 2,000 psi. Without these test pump facilities, it would have been impossible to have developed the Mud Monarch Valve whose superiority has been proved in hundreds of field installations.

Nothing but the finest will bear the name of **MISSION MANUFACTURING CO.**

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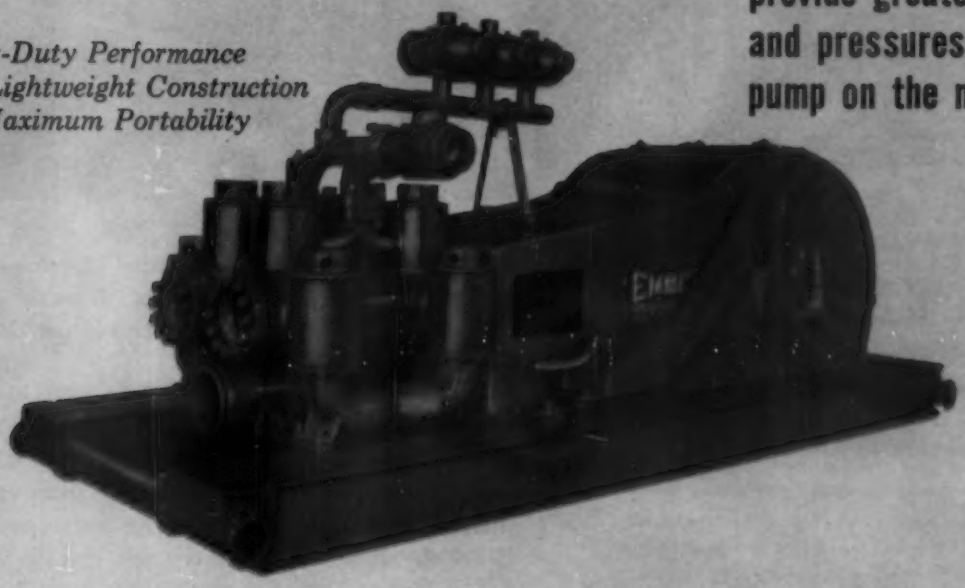
provide greater volumes and pressures than any pump on the market!



1 Fabriform construction of the power end, originated and developed by EMSCO, uses steel plates and shapes instead of bulky, heavy iron castings and provides a light, rigid frame.

2 Wide-faced, forged steel, heat-treated herringbone gears provide quiet and efficient speed reduction.

3 EMSCO's patented "exposed" liner design eliminates all fluid washouts caused by liner packing failure since the slightest leak may be detected immediately.

4 Operation and maintenance are simple and easy. There are no adjustments to be made, no greasing to be done. Lubrication is completely automatic.

5 Fluid end is of 8-pot design, with each valve in a separate pot or valve chamber. Threaded valve-pot covers provide quick and easy access to valves—reduce bulk and weight.

6 There's an EMSCO Slush Pump for every pumping need—six models: D-175, D-300, DA-500, D-700, D-850 and D-1000. Call your EMSCO representative for full information.

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SP-C

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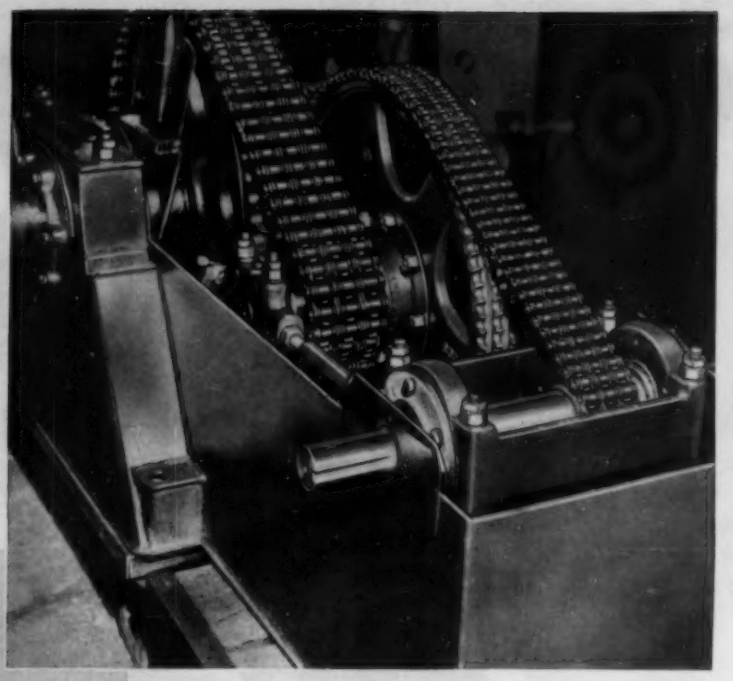

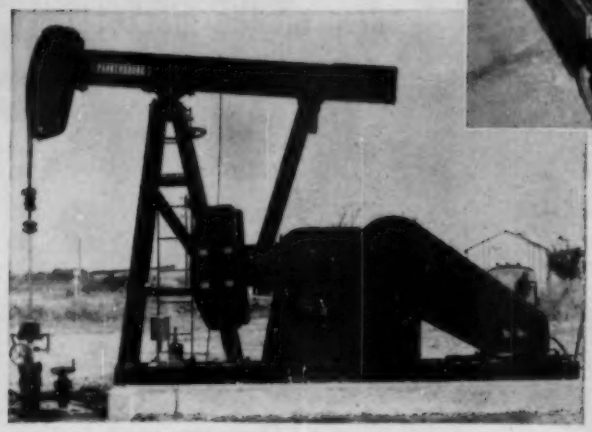

Larger Parkersburg Pumpers than the one shown above have Diamond Chain Drives and peak torque ratings of up to 265,000 pounds!

ALWAYS PRELOADED For many, many years, Diamond Chain has been preloaded after assembly for the purpose of bringing pin-bushing seating into stabilized relationship prior to field installation.

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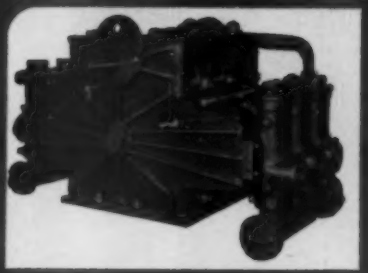
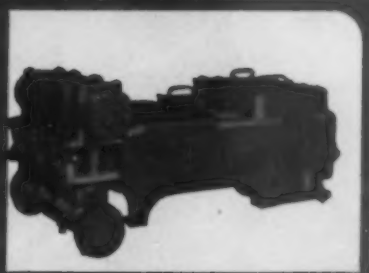
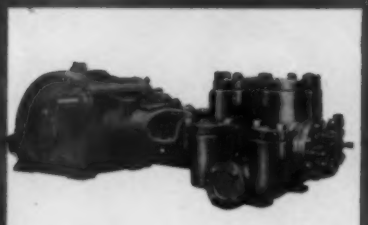
PL-7



PA-8

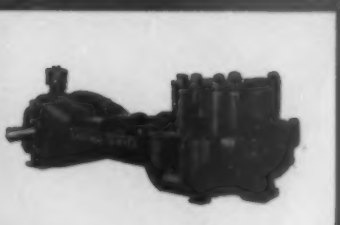
PE-5





FG-FXG

FF-FXF



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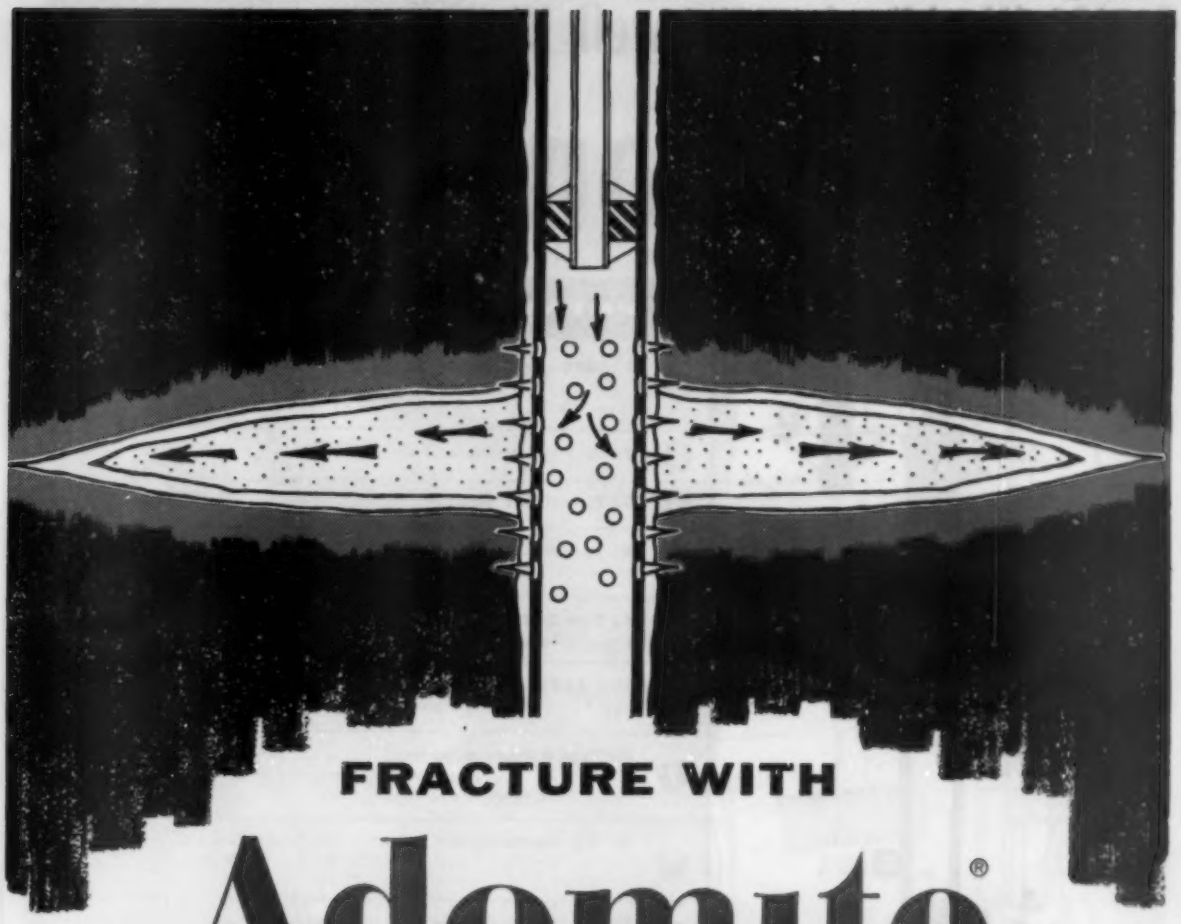

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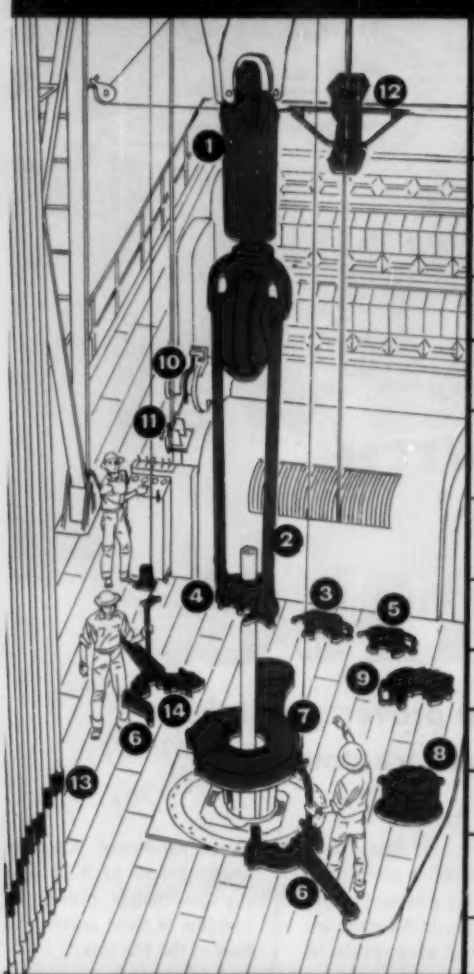
EQUIPMENT AND PERFORMANCE DATA



1. **BJ 4300 Super-Triplex Hook:** Supported drill string of 13,000' 4" O.D. pipe and 10,000' 2⅜" O.D. pipe (total weight 270,000 lbs.) Also handled 13,486' of 9⅝" casing (530,000 lbs.).
2. **BJ 2¼" x 132" Weldless Links:** Same performance characteristics as hook.
3. **BJ Type MGG 5" Elevator:** Used for top hole pipe handling.
4. **BJ Type MGG 4" Elevator:** Handled 13,000' of 4" O.D. pipe (5¼" tool joints) and 10,000' of 2⅜" O.D. pipe with a total weight of 270,000 lbs.
5. **BJ Type MGG 2⅜" Elevator:** Handled 10,000' of 2⅜" O.D. pipe (4¼" tool joints) with a total weight of 90,000 lbs.
6. **Two BJ Type B Tongs:** Handled make-up and break-out on pipe and casing from 2⅛" to 13⅜" O.D. (includes more than 150 round trips).
7. **BJ Type B Power Slip:** Handled and supported 13,000' of 4" O.D. pipe and 10,000' of 2⅜" O.D. pipe with a total weight of 270,000 lbs. Completely power-operated slip setting and raising.
8. **BJ 13⅜" Casing Spider:** Used to handle casing program including 3,003' of 13⅜" surface casing weighing 120,000 lbs. and 13,486' of 9⅝" casing weighing 530,000 lbs.
9. **BJ 13⅜" Casing Elevator:** side-door, slip grip: Elevator inserts were changed for casing size only (see #8 above) with no visible wear throughout entire program.
10. **BJ Type A Rope Guard,** driller's side: This safety attachment prevented catline fouling.
11. **BJ Catline Grip,** right hand: Held catline secure without damage through entire operation.
12. **BJ PB Wire Line Guide:** Used to absorb whip, lash and traveling waves of drilling line through entire operation.
13. **BJ PB Regular Type Protectors:** Used exclusively and installed one to a stand. Oil base mud with bottom hole temperature of 350°. No slippage or visible deterioration.
14. **BJ Red Top Tong Dies:** Used exclusively.

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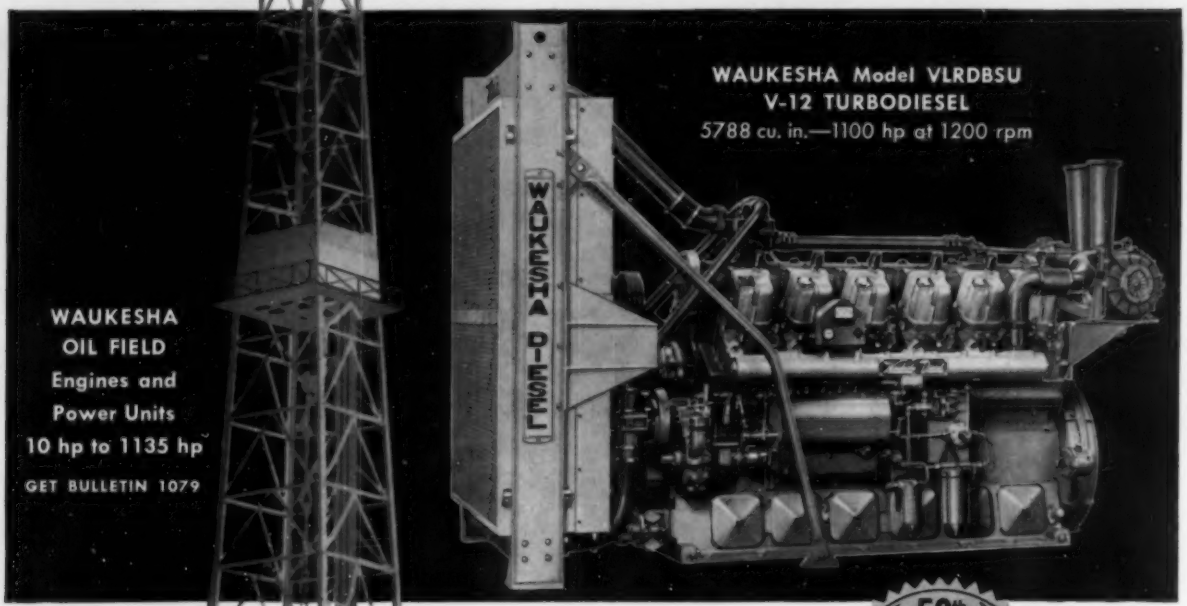

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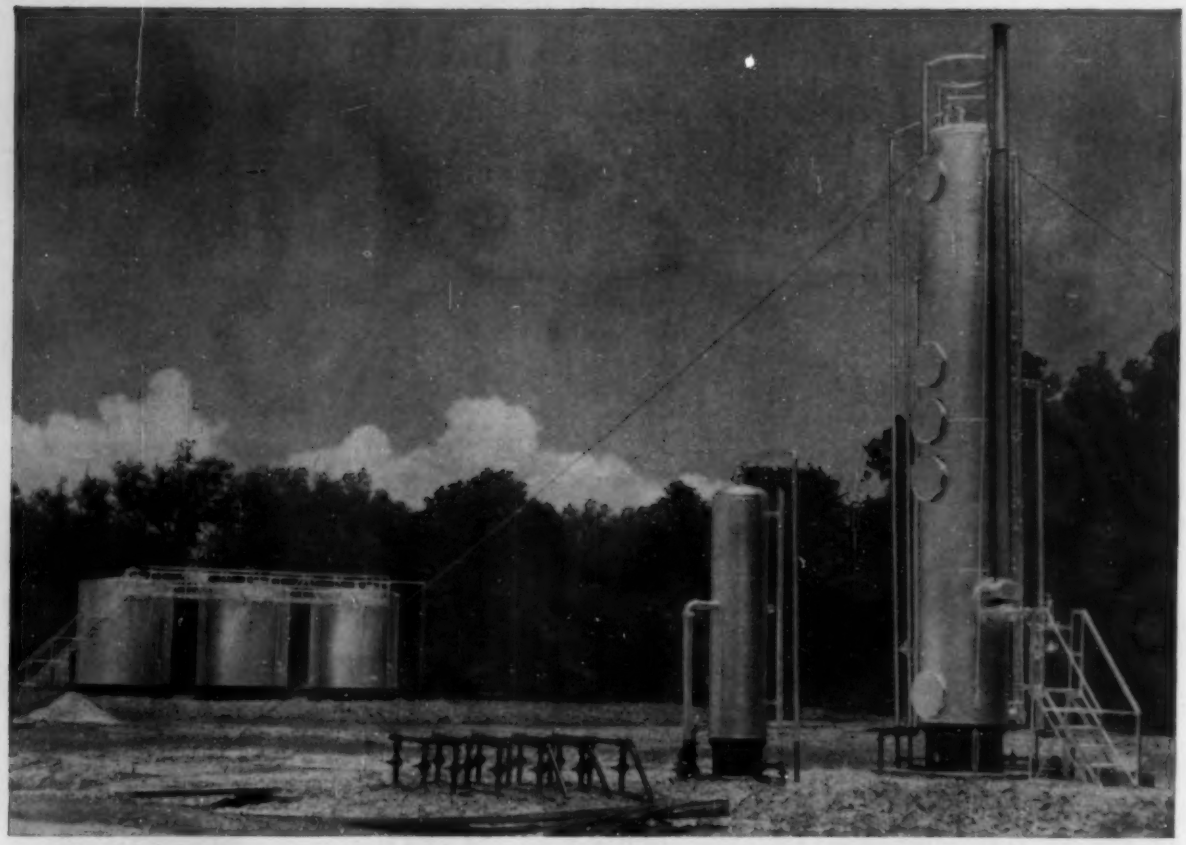

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In addition, Union Tank's trained sales and service representatives can help you select the most efficient new equipment for your well and solve tough hook-up problems. And Union's dependable service is available to help keep operations at maximum efficiency.

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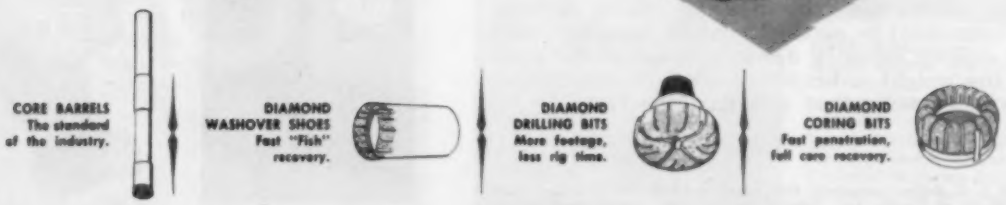

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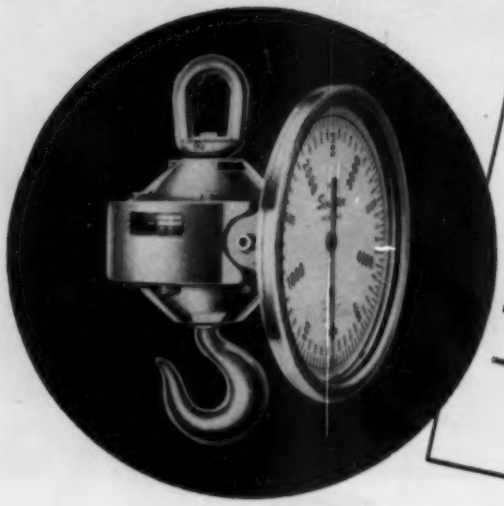
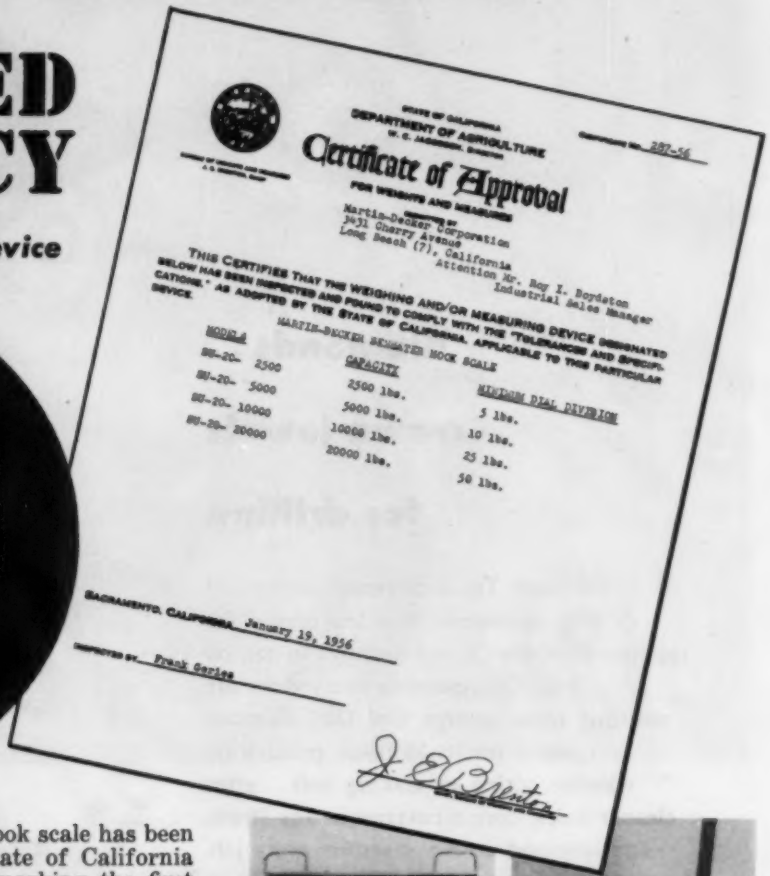




STATE OF CALIFORNIA
DEPARTMENT OF AGRICULTURE
W. C. JAGGERS, Director

Certificate of Approval

FOR WEIGHTS AND MEASURES

Issued to
Martin-Decker Corporation
3631 Cherry Avenue
Long Beach (7), California
Attention Mr. Roy I. Boydston
Industrial Sales Manager

THIS CERTIFIES THAT THE WEIGHING AND/OR MEASURING DEVICE DESIGNATED BELOW HAS BEEN INSPECTED AND FOUND TO COMPLY WITH THE "TOLERANCES AND SPECIFICATIONS," AS ADOPTED BY THE STATE OF CALIFORNIA, APPLICABLE TO THIS PARTICULAR DEVICE.

MARTIN-DECKER SENSATER HOOK SCALE

MODEL#	CAPACITY	MINIMUM DIAL DIVISION
SU-20- 2500	2500 lbs.	5 lbs.
SU-20- 5000	5000 lbs.	10 lbs.
SU-20- 10000	10000 lbs.	25 lbs.
SU-20- 20000	20000 lbs.	50 lbs.

SACRAMENTO, CALIFORNIA, January 19, 1956

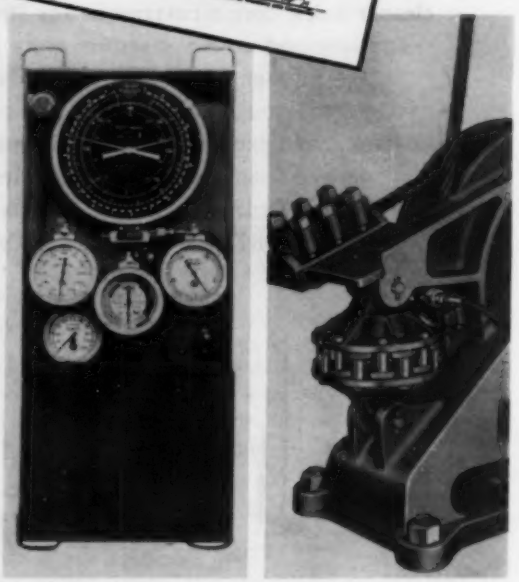
INSPECTED BY: Frank Garlets

Martin-Decker's SU-20 Sensater hook scale has been approved for certification by the State of California Bureau of Weights and Measures, marking the first time that a heavy-duty industrial weight indicator of this kind has ever been accurate enough to be certified *in any state.*

The SU-20 Sensater operates on the same mechanical and hydraulic principles as the E-80 Sensater, the pressure transformer that actuates the Martin-Decker Type "D" or "E" drilling-control instrument. Both the SU-20 and the E-80 use Martin-Decker's patented diaphragm that strokes like a piston — but with no friction whatsoever.

It may not be necessary that an oilwell drilling-control instrument be certified. But, if the time comes that the drilling industry demands proof of the accuracy of the weight indicators it uses, Martin-Decker has the instruments that will pass the test.

DISTRIBUTORS: T. C. Cullen, Bakersfield, Calif., Reed Roller Bit Co., Houston, Texas; Reed Roller Bit Co. of Canada, Ltd., Calgary and Edmonton, Alberta. Martin-Decker weight indicators and Ideal wire line anchors are also sold through The National Supply Co., The National Supply Co. Export Division and other recognized supply houses.



The Martin-Decker Type "D" drilling-control instrument derives its accuracy from the signals transmitted by the supersensitive E-80 Sensater installed as an integral part of the Ideal wire line anchor.

MARTIN-DECKER CORP.

HOME OF THE WEIGHT INDICATOR ——— LONG BEACH, CALIFORNIA

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What makes a cylindrical roller bearing good?

RETAINERS

"requirement-engineered" for your kind of service

The basic parts of a roller bearing are the rollers, the races, and the *retainer* which locates and guides the rollers. There are significant differences in the design and construction of retainers, which influence bearing cost and performance. Some are simple and economical, well adapted for volume production; others are more costly but insure improved roller guidance, or cooler and smoother operation, or longer heavy-duty service. Here are the seven basic types in current use.

HYATT MAKES ALL SEVEN TYPES . . . EACH THE FINEST OF ITS KIND! You will find complete details in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type best suited to your requirements. Remember, HYATT is America's *first* and *foremost* maker of cylindrical roller bearings. Hyatt Bearings Division of General Motors, Harrison, New Jersey.

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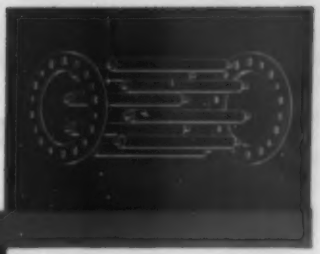
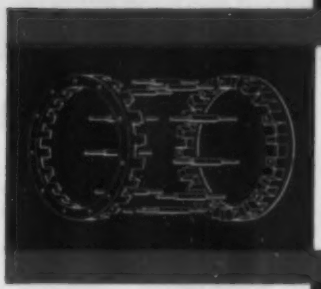
HYATT ROLLER BEARINGS

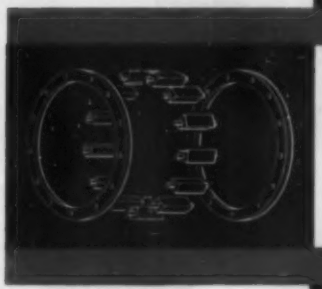
TRUNNIONED ROLLER CAGE—Economical for volume use on thin-annulus bearings. End rings are hardened steel stampings, connected by riveted bars interspersed between rollers to form an integral unit. Races can be omitted if desired.





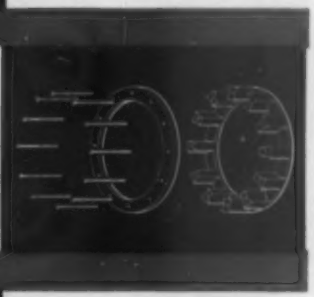
POCKETED END RING CAGE—Designed for fairly large bore bearings in heavy-duty service. Rollers are guided accurately by pockets drilled in bronze end rings. Riveted connecting bars form an integral unit, so races can be omitted if desired.

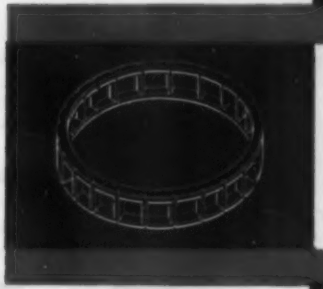
STAMPED STEEL SEPARATOR—Economical for volume use on wide range of bearings with short rollers. A single steel stamping with bars coined to conform to roller contour. Simple, open design assures large lubricant capacity and good circulation.



FORMED BAR CAGE—Well adapted for volume use on heavy-duty bearings. Hardened steel end rings are connected by cold-rolled shaped bars conforming to roller diameter. Insures quiet operation, better roller guidance, and the smooth surface of bars protects rollers.

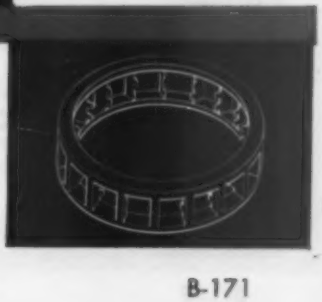
DRILLED POCKET CAGE—Used on better-grade bearings to provide extremely close control of rollers, which operate in pockets drilled and reamed in bronze cylinder. Riveted ring on one end retains rollers permanently, so races may be omitted if desired.



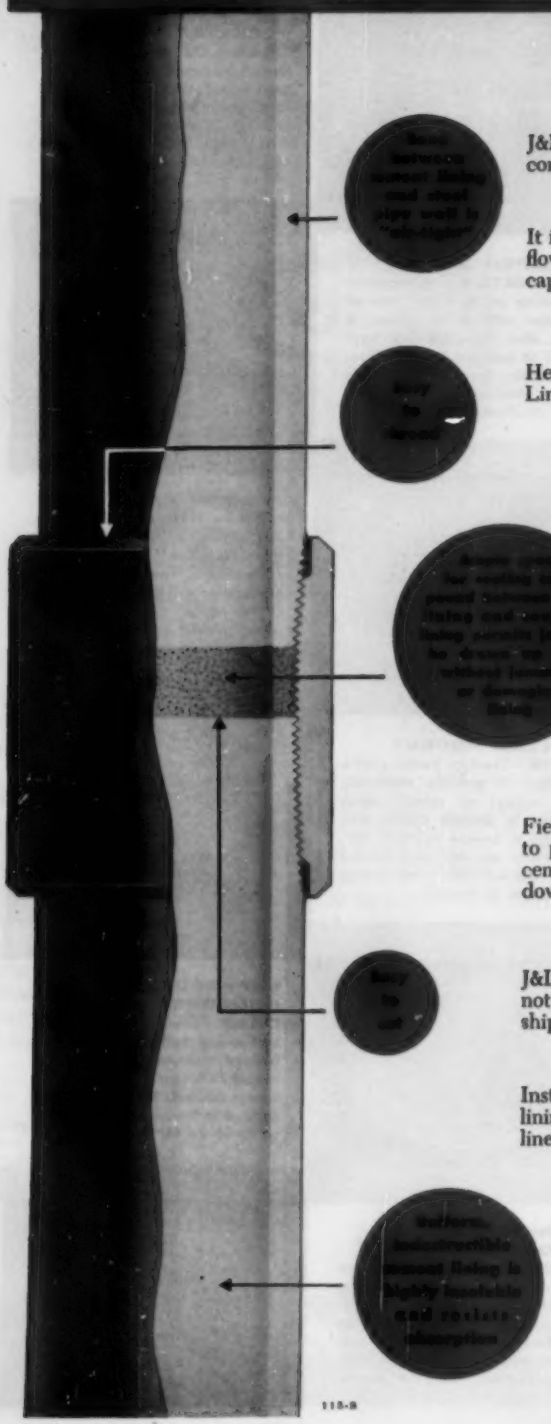


SEPARABLE BROACHED POCKET CAGE—Used only on finest high-speed bearings. An integral bronze cylinder with pockets broached for maximum uniformity. Insures minimum friction, better oil circulation for cooling. Rollers can be removed for inspection.

NON-SEPARABLE BROACHED POCKET CAGE—Similar to the above and offers all the same operating advantages. Used for "blind" installations where rollers must be retained with inner or outer race. Roller drop controlled by deforming bars after rollers are placed.



J&L CEMENT LINED CASING, TUBING, LINE PIPE



USES-ADVANTAGES

J&L Cement Lined Steel pipe is designed specifically for handling corrosive liquids.

●

It is satin smooth, resulting in a lower friction coefficient and higher flow efficiency than for unlined pipe. Therefore, the carrying capacity is greater than steel pipe of the same I.D.

●

Here are a few of the many applications in which J&L Cement Lined Steel pipe offers outstanding advantages:

1. Lines in salt works for handling brine.
2. Lines in process plants where water or other liquids must be kept free from iron contamination or rust.
3. Oil field flow lines, pipe lines, tubing and casing, where salt water, hydrogen sulfide, carbon dioxide and other corrosive materials are present.
4. Lines in paper and pulp mills for handling diluted acids and corrosive waste liquids.
5. Discharge lines in coal mines for carrying highly corrosive sulphur water.
6. Hot water lines where ordinary pipe is subject to tuberculation.
7. Municipal water works systems.

Field joints are made up with a putty-like sealing compound, easy to prepare and use. It affords protection at this point equal to the cement lining in the pipe. Field joints can be made up and broken down as often as necessary without damage to the cement lining.

●

J&L Cement Lined Pipe will withstand any exterior blow that does not dent or deform the steel. It requires only normal handling in shipping and unloading.

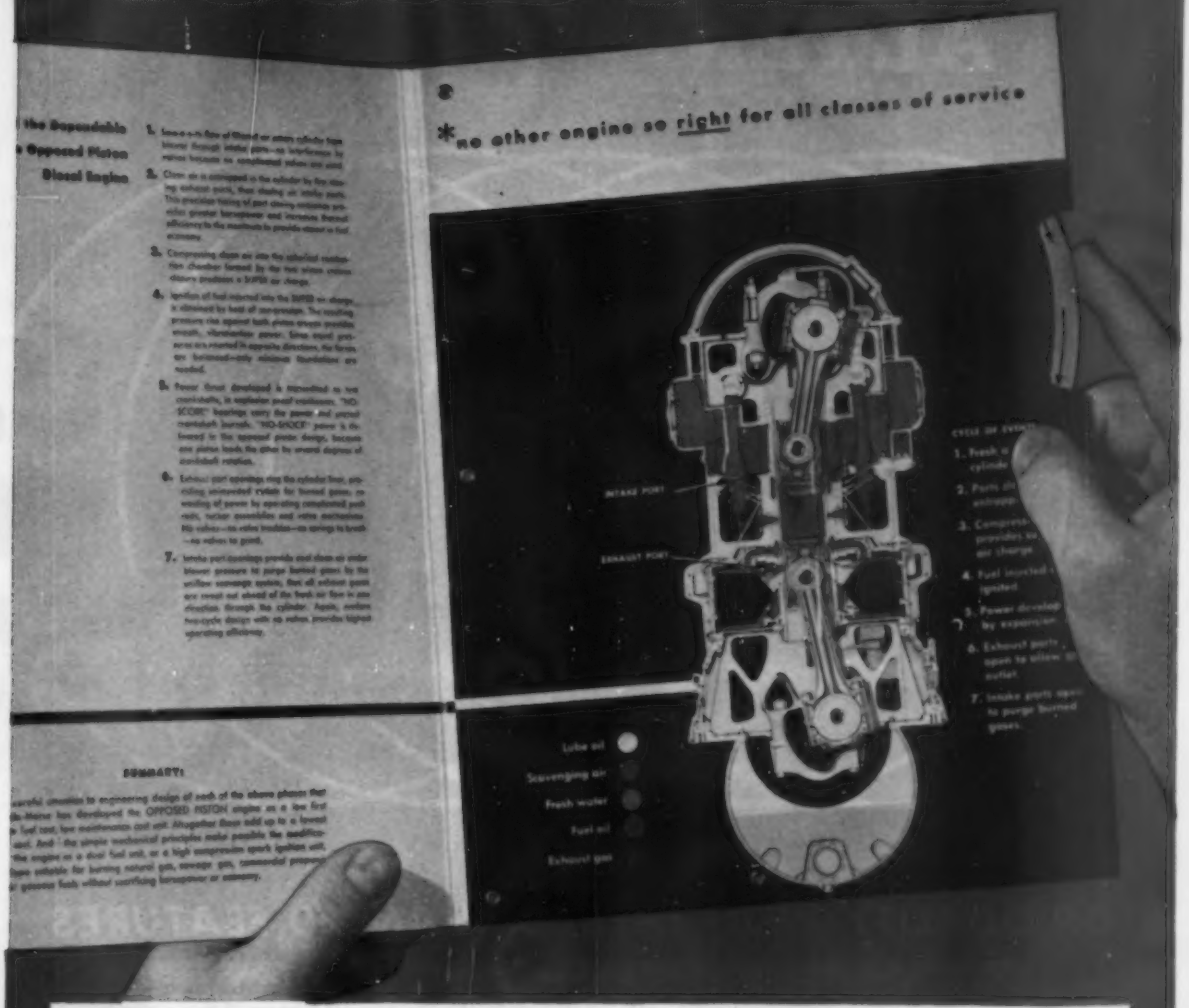
●

Installation requires no special knowledge or skill. The pipe and lining can be cut with a metal saw, or a power bandsaw. Cement-lined tees, ells, crosses, unions, and other fittings can be supplied.

Jones & Laughlin
STEEL CORPORATION
SUPPLY DIVISION – TULSA, OKLAHOMA
Serving The United States and Canada

"Working Model" of the Opposed-Piston Diesel

YOURS FREE



Here in Graphic Full Color

is a detailed working model of the Fairbanks-Morse Opposed-Piston Diesel Engine—and it's yours free for the asking.

With the 8-inch operating cutaway in front of you, you can follow the complete operating cycle of this outstandingly successful heavy-duty engine designed for continuous service. Moving the disc at the right operates the model showing exact position of pistons, and color codes condition in the cylinder, throughout the entire cycle of events.

You'll also see the simplicity of the O-P that has no valves, intricate valve trains, cylinder heads and gaskets—in fact, it has 40% fewer moving—wearing—parts than any comparable engine of equal horsepower.

If you are interested in dependable power with low operating and maintenance cost, send for your working model of the O-P diesel today! Simply attach this advertisement to your letterhead (or ask for O-P "Working Model") and send to Fairbanks, Morse & Co., 600 S. Michigan Ave., Chicago 5, Illinois.

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ALTEN Pumping Units

A FULL LINE OF 47 MODELS AND TYPES FROM 6000 IN. LBS. PEAK TORQUE TO 320,000 IN. LBS. A. P. I.—ALL

TOP QUALITY WITH THESE ADVANCED FEATURES

Screw type adjustable counterbalance with locking device and calibrations (one man may adjust with safety while standing on the ground). ... Forged steel gears---Helical or herringbone gear reducers.... Saddle provides four-way walking beam adjustment.... Bronze bushed long life saddle bearing.... Self aligning roller wrist pin bearings.... Tapered wrist pin cannot rotate in crank.... Internal expanding automotive type brake of ample capacity.... Over-the-beam equalizer.... Rugged, samson post and frame.... Adjustable horsehead may be swung back over the beam for well servicing.

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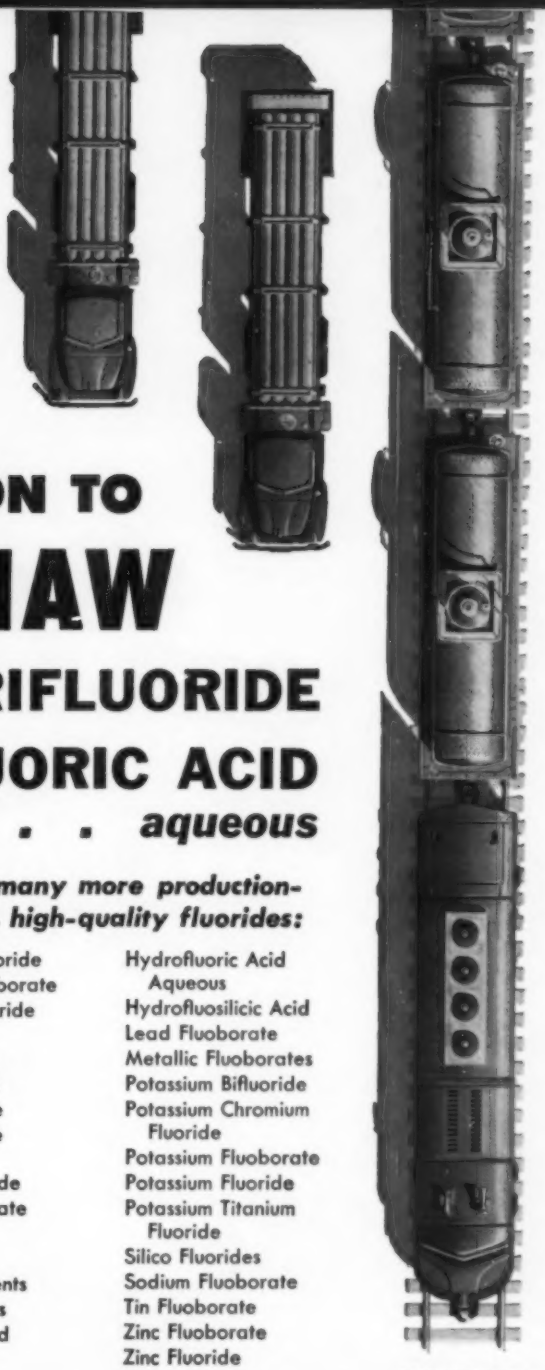

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anhydrous . . . aqueous

Here are many more production-controlled, high-quality fluorides:

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Hydrofluoric Acid Anhydrous
Hydrofluoric Acid Aqueous
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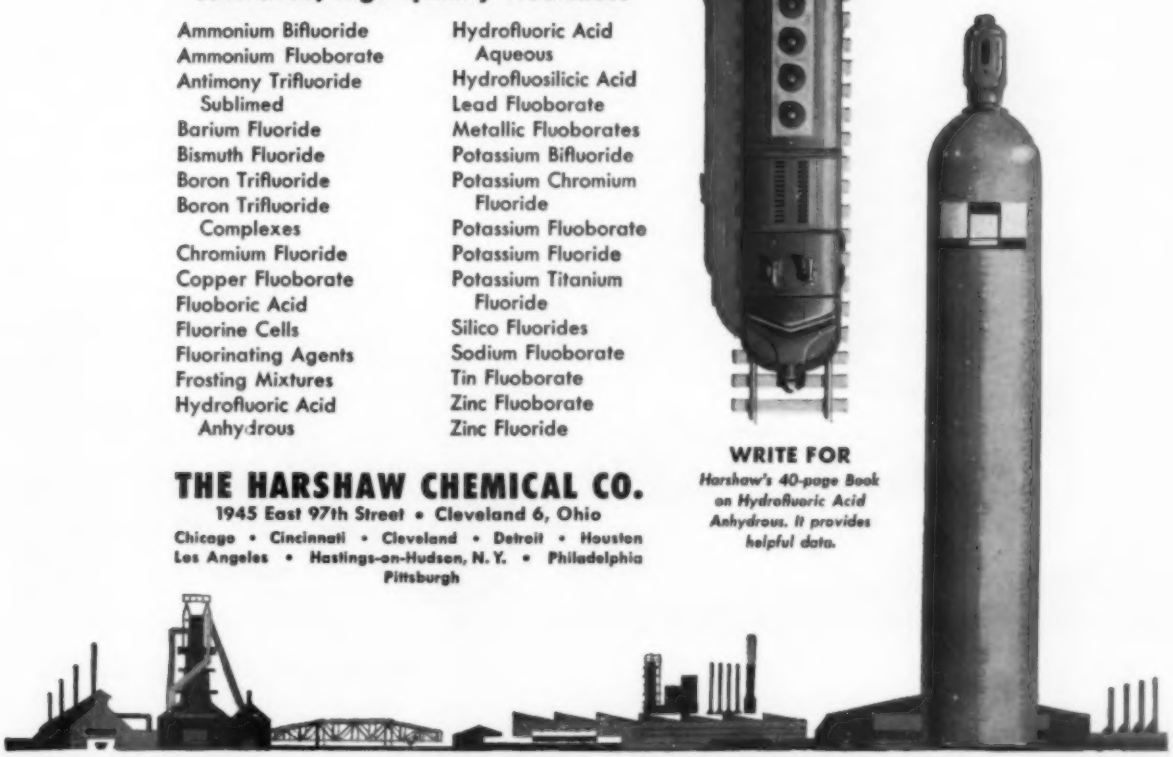
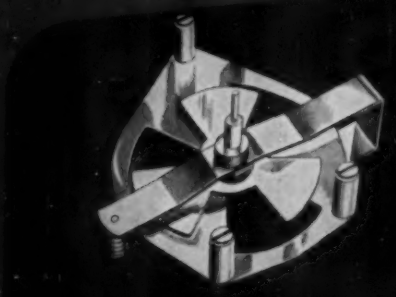
Harshaw's 40-page Book on Hydrofluoric Acid Anhydrous. It provides helpful data.





In DYNALOG Instruments, a simple, radio-type, variable capacitor replaces the troublesome slidewire — gives unmatched smoothness of balancing.

this potentiometer has no slidewire

STEPLESS CAPACITY-BALANCING PROVIDES SPEED WITHOUT WEAR!

Friction-free balancing action! That's why Dynalog responds almost instantly to the slightest changes in a process variable . . . without wear . . . with *lasting* high accuracy.

The DYNALOG has no fast-moving parts . . . and no gears, cables, or complicated mechanisms to slow response. Sensitivity isn't limited by slidewire windings. A simple, variable capacitor and positive magnetic drive provide continuous, stepless balancing with a sensitivity of 1/100 of 1% . . . an accuracy of ¼ of 1%. And DYNALOG is never "off process" for standardizing — it requires *none*. There are no batteries to replace . . . no motors to periodically clean and lubricate. Only five moving parts!

DYNALOG'S* EXCLUSIVE BALANCING ACTION

- no slidewire
- no batteries
- no standardizing
- no gears, cables, etc.
- no high-speed reversing motor

DYNALOG Instruments can be used with resistance, voltage, capacity, or inductive type primary elements to measure and/or control any process variable with unmatched speed and accuracy. Write for Bulletin 427. The Foxboro Company, 644 Neponset Ave., Foxboro, Mass., U.S.A.

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DYNALOG

ELECTRONIC INSTRUMENTS

NEWS and COMMENT

Scientists – Fuel Pumps – Atom Smashers – Automation

ONE PUMP! TWO TANKS! — FIVE GASOLINES! Now — Ain't that Sump'n! Sun Oil Company, with a "weakness" for doing the unusual, has instituted, at 17 retail service stations in Florida (Orlando), an epoch-making step in supplying motor fuels to motorists. Two tanks — one contains the company's regular Blue Sunoco grade of gasoline, at something like 93-94 research octane number; the other tank contains a special "octane-concentrate" liquid of undisclosed rating, both tanks being connected to a special patent-applied-for-by-Sun proportioning pump. This pump was developed by Sun specially for this purpose and Wayne Pump Company built them. Five grades of motor fuels may be supplied at the request of the motorist, merely by setting controls that send in the requisite proportions of the two products to yield the grade called for. Grade five presumably will have more than 100-octane number, so the concentrate probably contains alkylate, aromatics and quite possibly (?) tetraethyl lead or other octane booster. Sun Oil has plenty of cat cracking and reforming capacity, also can concentrate aromatics by an Arosorb process, so the concentrate is no problem.

The grades may vary somewhat more than one octane number between two "adjacent" grades, and Sun, while setting no flat requirements, has suggested that dealers make a price differential of about one cent between grades in the scale. Thus, if Blue Sunoco is selling at 28 cents per gallon, then grade 2 would be 29 cents, and grade 5 32 cents. If this system should "catch on" in motorists' imaginations, it will revamp the entire system of retail marketing of motor fuels. Station operators are briefed in the octane requirements of present-day cars on the road, to aid motorists in deciding which grade to buy.

★ ★ ★

THE OCTANE RACE is heating up, according to recent developments — Great Lakes Pipe Line Company will send 96-octane number premium fuel through its line toward the Great Lakes region, instead of the 94 rating currently standard for that 180,000 B/D artery. Heavy octane competition on the East Coast has spread to the Central Area and the Midwest. Independent refiners are "looking at the hole card" to see what is best for them to do in meeting this competition. Race is largely on premium grades and looks to the market provided by higher compression-ratio engines, mainly in higher priced cars. Most Midwest and western refiners believe that no cause exists for raising octane ratings for regular or house-brand fuels. Meeting the octane boost on premium is not critical for most refiners, but to raise two numbers on regular gasoline would set some of them by the ears. The continued climb in octane rating has caused shutting down of at least one refinery, Johnson Oil Refining Company of Cleveland, Oklahoma. Estimates of added cost for raising regular two octane numbers are 18¢ to 25¢ per octane number; for premium grade 24¢ to 32¢ per number.

★ ★ ★

A 15 PER CENT PROFIT plus the rubber required to win World War II closes the chapter on synthetic rubber plants built by the U.S. Government and now sold to private industry. Spending nearly a billion dollars for these various plants, this sum has been returned to the U. S. Treasury by the sale of the plants, and some $150,000,000 in addition. And possibly the greatest advantage of all is the fact of our being made independent, in a crisis, of foreign sources of natural rubber, a situation that almost tipped the scales of war in favor of Japan and Germany. By about 1960-61, we shall require 3,500,000 tons of rubber annually; we now use 2,885,000 tons. By 1961, we must add 400,000 tons of capacity, foreign natural or domestic synthetic or both combined. Pricewise, we can avoid natural suppliers' arbitrarily raising the price as they choose, since the cost of synthetic has been reduced drastically and will limit any such boost.

★ ★ ★

THREE SYMPOSIA, on "Chemicals from Petroleum," "Corrosion in the Petroleum Industry," and "Chemistry in Exploration and Production of Petroleum" will signalize the petroleum meetings of the American Chemical Society's Petroleum Division in Dallas, April 8-13. The last two subjects will be presented jointly with the Division of Industrial and Engineering Chemistry, and Division of Colloid Chemistry, respectively. The impact of the automobile on the nation's chemical economy will be one of the more important general discussions before this huge body of chemists, 4500 strong. Dr. C. S. Marvel, authority on synthetic polymers, will receive the Priestley Medal, highest honor within the gift of this largest scientific society.

EIGHT CARBURETORS or none at all seem to make little difference to modern automotive gasoline engines, to judge from recent reports. Operating a test engine with eight separate carburetors enables engineers of the staff of Esso Research and Engineering Company to determine the comparative performance of eight different fuel mixtures in the same run. Obvious advantage of this plan is that all engine operating conditions can and will be the same for each fuel; engine can be kept running all through the test, while one after another of the carburetors with its different fuel can be switched in to supply the engine exclusively with fuel, and the performance checked on a comparative basis. Speak of hydra-headed monsters!

The same crowd is testing a European car with *no* carburetor; it is equipped with a fuel injection system by which the motor fuel is pumped into the cylinder or fuel system directly, not aspirated into the manifold as in a conventional carburetor. Outcome of this investigation, and similar projects by other fuel and car manufacturers, may have a most important effect on motor fuel refining processes of tomorrow.

★ ★ ★

BRINGING THE MOUNTAIN to Mahomet may be the answer to the Why? of Phillips Petroleum Company's building a $3,000,000 industrial area, complete with utilities and facilities required for industrial factories, with no company plans for any such installations on the nearly 1000 acres on the Houston, Texas, Ship Channel. Water treating capacity, railroad switch lines, power inlets, etc., and will then sell areas to industrial companies wanting locations. WHY?

Sum it up: Much petrochemical capacity is located in the Gulf Coast area, more is being built. Chemical and other companies are now looking for building sites, where water hauls, rail transport and raw materials are available at, hopefully, lower than maximum prices. Light natural and refinery — gaseous hydrocarbons are raw materials for innumerable petrochemicals and chemical intermediates. Natural and refinery gases consumed within the borders of the state of origin are not subject to Federal regulations. Phillips has large reserves of natural gas in Texas, also a refinery on the coast at Sweeny, below Houston and in easy pipe line distance of the channel.

What Do You Guess?

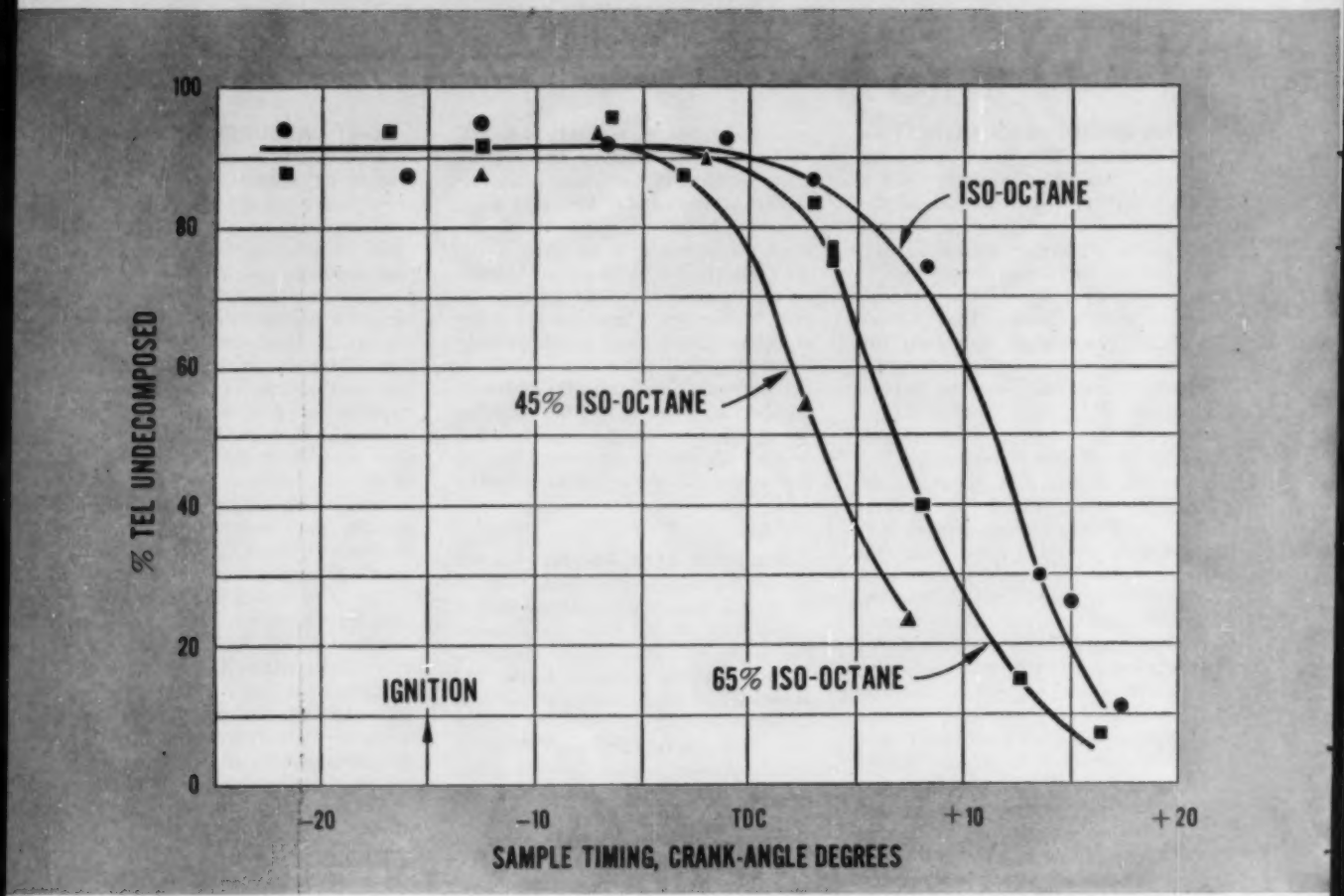


Fig. 1. TEL decomposition in fired engine. Fuels: mixtures of iso-octane and n-heptane containing 6 ml TEL per gallon.

New research on antiknock action

by ELLIS B. RIFKIN
Ethyl Corporation, Detroit, Mich.

Although tetraethyllead is widely used as an antiknock agent, some fundamentals of its action are still not completely understood. Since a full understanding of the mechanism of its action could presumably lead to increased effectiveness of utilization—the Ethyl Corporation conducts a continuing basic research program on antiknocks.

Many theories concerning the mechanism by which tetraethyllead acts as an antiknock in the internal combustion engine involve either the process by which tetraethyllead decomposes or the products resulting from such decomposition.

This report describes the studies of variables affecting the decomposition of tetraethyllead both in fired engines and in motored engines.

In a first series of experiments, a spark-ignited, fixed-compression ratio, L-head engine was employed. This engine was equipped with a sampling valve of special design which permits repetitive extraction of small samples from the end-gas region of the combustion chamber.

Mixtures of iso-octane and normal heptane were used as fuels, and end-gas samples were taken at 5° intervals from 25° before top center to 20° after top center. The results of these studies are indicated in Figure 1 which shows:

1. That essentially all the tetraethyllead is decomposed before the mixture is consumed by the flame front.

2. That the rate of tetraethyllead decomposition is markedly affected by fuel composition.

In order to resolve this effect of fuel composition more completely, it was decided to conduct a second series of experiments—this time in a motored engine, to permit measurement of temperatures. A single-cylinder engine was again used, but in this series of experiments, the engine was of the variable-compression ratio type to permit variation of temperature and pressure of the fuel-air mixture over as wide a range as possible.

Mixtures of iso-octane and normal heptane as well as di-isobutylene were the fuels tested. Figure 2 illustrates the effect of fuel composition on tet-

(Advertisement)

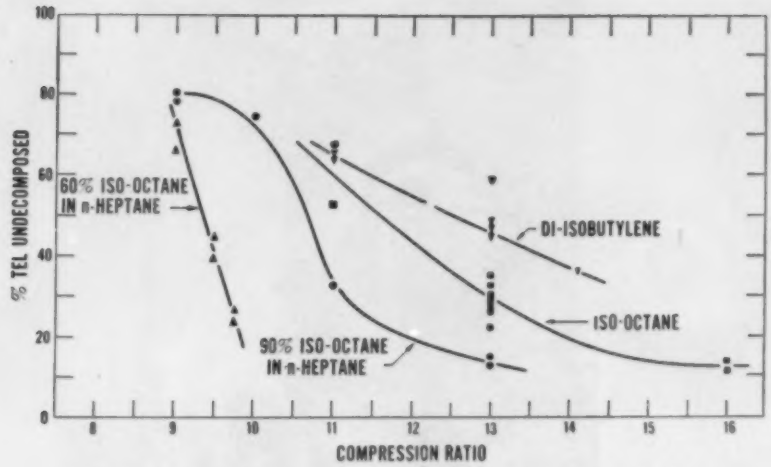


Fig. 2. Effect of fuel on TEL decomposition in a motored engine.

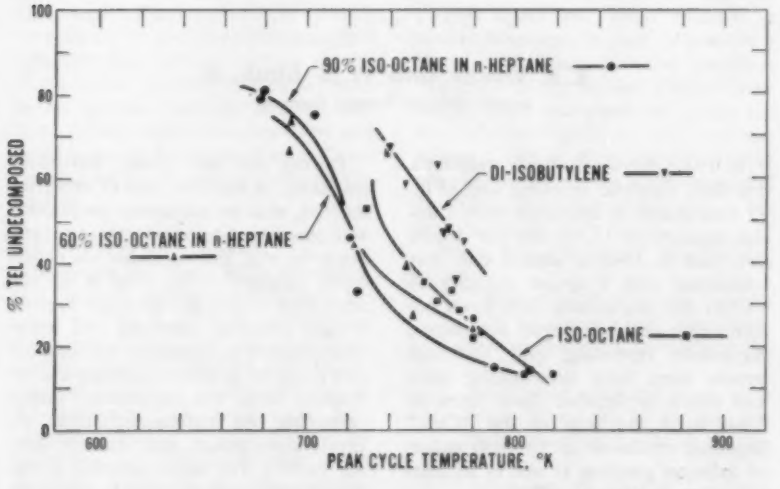
raethyllead decomposition in the motored engine—somewhat comparable data to that shown in Figure 1 for the fired-engine studies.

Again, an apparent correlation was obtained between fuel composition and rate of tetraethyllead decomposition—with the more rapid rates being associated with fuels of higher octane number.

To gain still greater insight into this relationship, technicians calculated peak cycle temperatures and the tetraethyllead decomposition data were examined against this variable. The results of this work are shown in Figure 3. It can be seen immediately that most of the variation due to fuel composition has been eliminated. This leads to the conclusion that temperature may be the one basic variable governing the decomposition of tetraethyllead—and that fuel composition has only an indirect influence so far as it affects the peak temperature of the charge in the cylinder. A mathematical analysis taking into account the variation in temperature of the charge throughout the cycle and comparison of those data with tetraethyllead decomposition data confirm this conclusion.

This account of one typical research project in the Ethyl Laboratories is designed to give you in the petroleum industry a glimpse into the vast body of continuing research being carried out to guarantee the maximum effectiveness of "Ethyl" Antiknock Compound.

Fig. 3. TEL decomposition in four fuels related to peak cycle temperature.



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EXCLUSIVE

By proper and complete pre-turnaround planning, with "bottleneck" removal, actual throughput capacities have been tripled

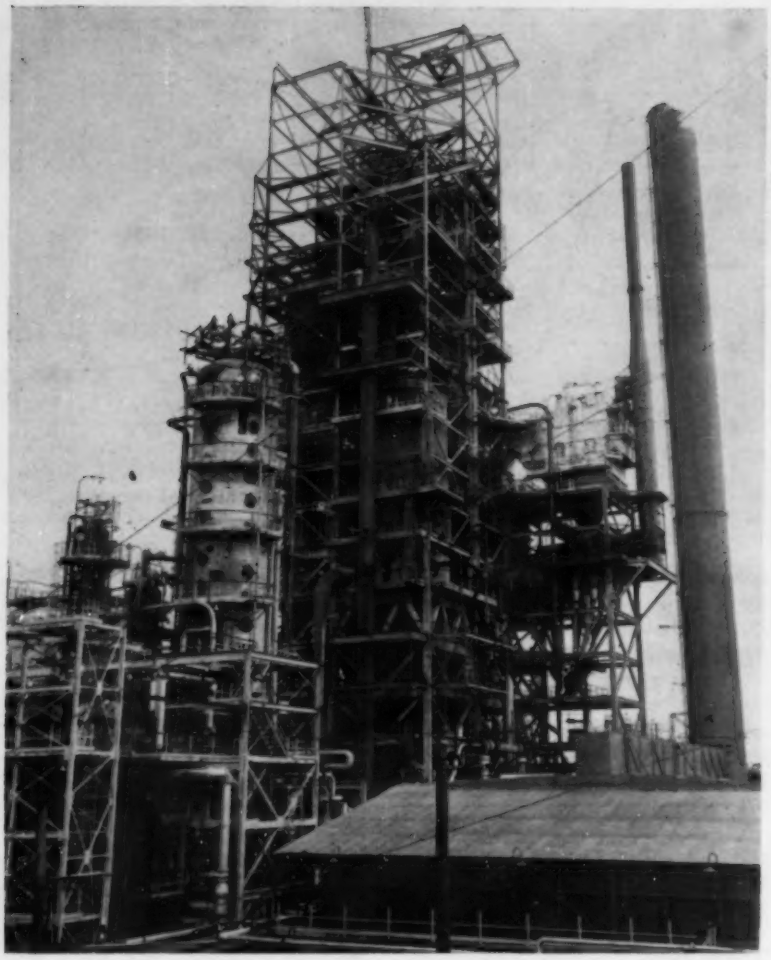


FIG. 1. Fluid cat cracker at start of turnaround.

When Does a TURNAROUND Begin?

R. R. Warne and W. B. Black, Jr.
Humble Oil and Refining Company

THE greatest factor in cat cracker efficiency is the percentage of on-stream time. The Turnaround requires shutting down the unit, inspecting and repairing all needed parts, installing all changes in the unit's design, and getting it back on stream in the shortest period of time. Planning the next Turnaround starts the day the unit is placed back on stream. One of our best refinery organizations plans, pre-arranges and carries out its turnarounds to give the lowest cost and the shortest downtime, thus the highest on-stream efficiency.

In 1942, Baytown, Texas, refinery's first fluid catalytic cracking unit (Fig. 1) was placed in operation with a design capacity of 13,500 bbl per stream day, and in 1944 a second unit was completed with a design capacity of 15,500 bbl per stream day. Even before either unit had begun operations, Baytown's operating and technical people were busy determining ways and means to increase these rates. In 1946, with the help of the "Cats," Baytown produced its billionth gallon of aviation gasoline as one of its contributions to the war effort.

During the war years, Baytown's emphasis, as was the case of other industries, was on maximum production with less attention being given to costs. Since the war, this emphasis has necessarily changed — the shoe is on the other foot — and all efforts are directed toward lowering operating and maintenance costs to withstand the competitive pressure of other industries and refineries. What was the answer? Lower operating and maintenance costs, increase throughputs, and improve service factors. The latter meaning to improve or increase run lengths and to de-

FIG. 2. View from the cat unit just prior to turnaround, showing the stock pile of replacement materials. The temporary shacks will be removed later.

FIG. 2A. Tools and materials are mobilized just before turnaround starts. In the left foreground, the parts of a vessel that will be replaced are laid out in order of assembly; each part is numbered carefully.

crease the number and length of downtimes. It was that simple, but what was the answer and how was it to be accomplished? All groups in Baytown were involved, and all have contributed toward and shared in the results.

Service Factor Committees

Service factor committees were formed and given the task of improving the service factors on each major unit or group of units in a common service. The Fluid Catalyst Unit Committee was one of the first and consisted of representatives from the Operating, Technical Service, Design and Maintenance Engineering, and Mechanical Divisions. The committee meets periodically to discuss all problems that influence the service factors of the "Cats." Each problem is then assigned to the particular division involved, and its recommendation is reviewed by and acted upon by the Service Factor Committee as a group with a common objective.

Throughputs Increased

Throughputs Have Been Increased, and the fluid catalyst cracking units are now operating at more than three times their design capacities. This has been accomplished basically by the Operating and Technical groups seeking out the "bottleneck" on the unit and continually removing it with various installations or revisions. Heat input has been increased with the installation of furnaces; additional blowers have increased catalyst circulation rates and carbon burning; improved cyclone design has improved separation efficiency; catalyst after-burning has been controlled with the utilization of water and steam sprays and automatic instrumentation; additional compressors have increased gas handling capacities, and improved reactor vessel designs have increased cracking severities.

Run Lengths Increased

Run Lengths have always been a major problem with the "Cats," and during the war years, a six-month run was considered very good. But there is always a reason for a short-run length or a unit shutdown. What brought it down? What can be done to prevent a recurrence? These are the questions that concern the Service Factor Committee; both individual and group action are then taken to work out the proper solution. Run lengths of over one year are now being experienced and an 18-month inspection schedule is anticipated in the near future.

Here are the chief contributing factors:

1. The maximum utilization of proper corrosion and erosion-resistant materials throughout the unit.
2. Slide valve seats and liners have been improved in design and hard surfacing materials are being utilized.
3. Lines and vessels are now lined with insulating refractory and covered with hexteel-reinforced castable wearing surfaces.
4. The original cyclone separators have been replaced with an improved design less susceptible to erosion from the catalyst.

Downtime Lengths

Downtime Lengths become the major factors toward improving service factors when the maximum utilization is being made of designs, materials, etc. to improve run lengths to meet the required inspection period. In addition, the efficiency with which the required downtime repairs are made is a major factor on the cost side of the ledger.

Major emphasis is now being given to turnaround planning. At Baytown, it is recognized that the turnaround planning of a major unit, such as the "Cats," is not a periodic or spontaneous operation. After the completion of each turnaround and prior to the following turnaround, a systematic sequence of events is followed in an effort to minimize the downtime. This sequence of events is shown by the table.

The Turnaround Planner

The Turnaround Planner, as a part of the Central Planning Group, is responsible for planning specific downtimes and his responsibilities are:

1. To formulate specific plans for the turnaround to be completed in the desired time.
2. To assure that all materials and

FIG. 3A. Hooking up at bottom of coke baffle, showing dip-leg piping in D-7 vessel. Near the end of the turnaround, many photos are taken to yield information for future planning; photographing is an important phase of the operation.

FIG. 3B. Note the tape, which gives an idea of the size of these replacement items.

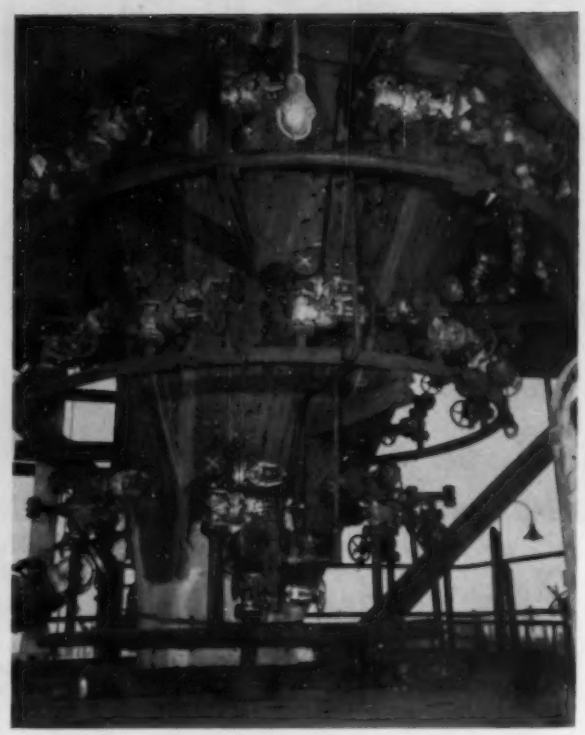


FIG. 3C. Rings on bottom cone of vessel D-7.

engineering services required will be available to accomplish the planned and scheduled work.

3. To assure that shops are notified in advance of all work required for turnarounds.
4. To maintain liaison in regard to engineering, materials, and shop work so that proper time sequences can be obtained for the various phases of the turnaround.
5. To assist the Zone Supervisor during the turnaround insofar as possible.
6. To revise turnaround plans, as necessary, during the progress of the turnaround.
7. To serve as a member of the Service Factor Committee.

The Turnaround Planner is assigned at the time a turnaround is scheduled and follows through on the assignment until the work has been completed and a final turnaround report prepared. With the "Cats," this is a continuous assignment following the sequence of events in the table.

Planning for the Next Turnaround Starts Immediately After the Last Turnaround

Immediately following the completion of the turnaround, the Mechanical Division calls a post-turnaround meeting to review the downtime and discuss possible improvements that can be made in performance of future turnarounds. Representatives from Operating, Engineering, Stores, and other divisions who were actual participants in the turnaround also attend. The following points are discussed at the meeting:

1. Actual performance vs planned and scheduled performance.
2. Factors significantly affecting the length of the downtime.
3. The amount of work added during the downtime and its effect on the downtime; and ways and means by which this work could be reduced or its impact lessened.
4. Suggestions for improving performance in the future.

Four Weeks After the Turnaround

Four Weeks following the completion of each turnaround, the Maintenance Engineers prepare a preliminary list of repair problems for the next downtime. This preliminary list is revised in the Service Factor Committee meeting, and the assignment of recommending proper action is given to the various divisions involved. The Maintenance Engineers, with the assistance of other divisions and the Service Factor Committee, develop solutions to the listed problems and submit recommendations to the Operating Division Management.

Eleven Weeks After the Turnaround

Eleven Weeks after the turnaround, the Service Factor Committee meets to review the Maintenance Engineers' recommendations along with any work proposed by others to be performed during the next turnaround. It is during and following this meeting that the Mechanical Division Turnaround Planner begins to function fully. It is his responsibility to accumulate all turnaround work information and systematically formulate a sound turnaround plan and schedule for work execution.

Twelve Weeks After the Turnaround

Operating Management requests the preparation of a formal estimate to cover the forthcoming turnaround, and this request is submitted no later than 90 days after the prior turnaround or 12 months prior to the anticipated downtime, whichever is later.

Interim Period

During the **INTERIM PERIOD,** the Project Engineer assigned to prepare the turnaround estimate is responsible for the following:

1. Obtain authorization to purchase material and have the required prefabrication and assembly performed. Fig. 2 and 2a show typi-

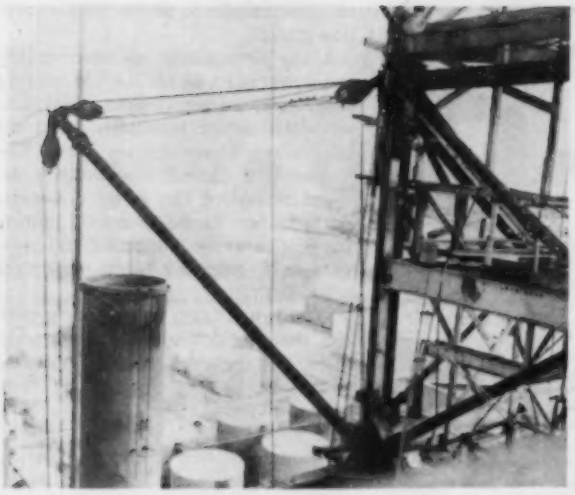


FIG. 4. A working boom is erected well ahead of turnaround time, on the 16th "floor" of the cat unit.

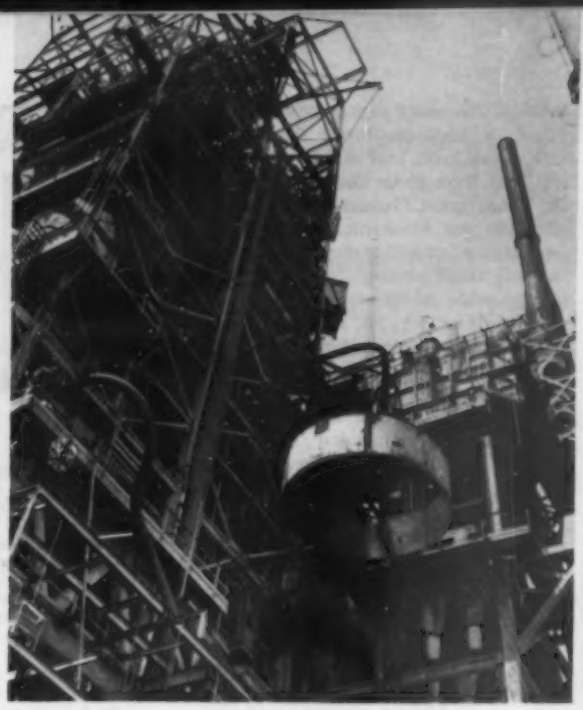


FIG. 5. The turnaround boom is lifting a section of a redesigned, "regenerated catalyst vessel." This one replaces four original vessels.

cal prefabrication and assembly that preceeds a major turnaround. The Turnaround Planner follows and coordinates these activities very closely as a service to the work execution group.

2. The release of design and drawing schedules and to see that any other preliminary work is done as required.

3. Act as an interim member of the Service Factor Committee.

The preliminary work list is made up item by item as additional work develops during the run. Each addition is handled through the Service Factor Committee, and the Turnaround Planner makes a detailed breakdown of the various work steps involved showing the Craft sequence and the time schedule agreed upon for efficient execution. The Service Factor Committee is responsible for periodically reviewing the downtime schedule to determine whether or not the unit should come down as scheduled.

Twenty-Eight Weeks Before The Downtime

Six Months prior to the scheduled downtime, a preliminary turnaround meeting is held. This meeting is called by the Operating Division, which notifies the various participants at least 4 weeks (28 weeks before the downtime) in advance of the meeting. All work items are in the hands of the Project Engineer two weeks prior to this meeting, and during the meeting he distributes the work list to be done during the downtime. Every effort is made to have the list as complete as possible and also to have all drawings and specifications on major projects ready for distribution. Twenty weeks prior to the downtime is the deadline for the completion of all engineering.

Sixteen Weeks Before the Downtime

Sixteen Weeks prior to the scheduled downtime, the Service Factor Committee meets to review the Mechanical Division's work schedule, which has been prepared by the Turnaround Planner. "Bottleneck" or controlling jobs are highlighted, and the downtime and pre-downtime work is discussed. Ways and means are discussed for reducing the total downtime length, and the payout for the extended downtime is weighed against the debit to determine if the controlling work is justified.

Thirteen Weeks Before the Downtime

Approximately one week prior to the final turnaround meeting, the Service Factor Committee presents a report covering the pertinent factors considered in planning the shutdown such as:

1. Reason for scheduling the unit to come down.

2. Estimated downtime and the resulting effect on operations including process debit.

3. Probable effects of the downtime on service factor of the unit.

4. Estimated cost of the work as compared to that of other prior turnarounds, along with other pertinent cost information.

5. A discussion of major items on the work list, including considered alternates.

6. Effects of proposed betterments on run lengths and/or throughputs.

7. Status of special plans and pre-downtime work.

8. The Committee's recommendations on factors that might be pertinent in making work execution plans for the downtime.

Twelve Weeks Before the Downtime

Approximately **Three Months** prior to the downtime, a final turnaround meeting is held at which time final work lists suitable for use in the field, along with plans made by the Turnaround Planner, are distributed. Purpose of the meeting is to provide a final check on materials, pre-fabrication, plans, schedules, etc., all of which are supposed to be complete. The intent is to have everything in readiness should the unit come down at any time following the meeting.

One Month Before the Downtime

During the Month, but not later than 2 weeks prior to the downtime, the Me-

chanical Divisions supervisory organization, to function during the downtime, is finalized, and various meetings are held throughout this period with the Turnaround Planner to make certain that the Mechanical Supervisors are familiar with the work to be performed. Many photographs taken during the prior downtime, such as those shown in Figs. 3A, 3B, 3C, are utilized fully in these meetings. Final work and supervisory assignments are made and final preparations are discussed to make certain that the downtime will be executed as scheduled. Following are some of the preparations that are made at the unit prior to the downtime that could significantly affect the length of the downtime:

1. A mobile tool room is located on the unit site and is fully stocked with tools and small stock materials that are known to be required. This tool room is equipped with telephones and a loud speaker system for communications throughout the unit.

2. A portable Mechanical Supervisors' office is located at the unit to be used as a regular meeting place during the turnaround. A mobile trailer is used for this purpose and is fully equipped with office and communications facilities.

3. Various permanent mechanical facilities on the unit are checked to make certain they are operating properly. Included among these are: (1) Hoists, as shown in Fig. 4 and 7, (2) elevators, (3) public address system, (4) telephones, (5) sanitary facilities, etc.

4. Maximum utilization is made of portable tubular scaffolds, and as many as possible are moved to the unit and erected prior to the shutdown to minimize delays in installing blinds, opening equipment, etc. In addition, temporary handling facilities such as trolleys and chain blocks are installed wherever possible.

5. Blinds, gaskets, valves, and other known items of materials are placed at the unit and tagged to indicate their place of use.

The Downtime

During the Downtime, the Turnaround Planner serves a very important function for the work execution forces. All work items that were not planned and scheduled prior to the downtime are directed to him and he is responsible for obtaining the necessary authorization, drawings, details, materials, etc. from the proper sources. Work that was not anticipated and is of major magnitude is discussed by the Service Factor Committee, which meets daily to make certain that the downtime of the unit remains under control and is not extended without the proper justification and authorization. The Mechanical Supervisors meet each morning to discuss the status of the overall turnaround schedule and to discuss the controlling jobs in detail, along with any new work plans that have been developed by the Turnaround Planner. A Shop Coordinator is utilized to follow turnaround work through the shops, to furnish job information to the Shop Planners, and to expedite shop schedules to coordinate with the unit downtime requirements.

Full utilization is made of fork lift trucks, crane cars, and pick-up trucks, which are available on the unit at all times. Ross carriers and rigging trucks are alerted to serve the downtime and are available through radio dispatching from the unit to move materials and equipment to and from the shops and storehouse as required. The Engineering, Storehouse, and Safety Divisions have representatives assigned full time to the downtime and are an invaluable assistance to the work execution group.

Many photographs are taken during the downtime and are used in making subsequent studies, designs, plans, and schedules, which materially affect the unit downtime and service factor. The Turnaround Planner also keeps a detailed record of the entire downtime performance to be discussed during the post-turnaround meeting and to be used in formulating future downtime schedules.

Baytown refinery management realizes that the downtimes can be minimized and the service factors increased with periodic or spontaneous turnaround planning. The full cooperation and coordinated group effort of all divisions involved following an accepted sequence of scheduled events toward a common goal is required. Is a turnaround ever actually complete? We think not. Sure, the downtime is past, but the planning for the next downtime begins the next week at the post-turnaround meeting. Past performance is reviewed critically as inspection findings in logging the time for planning the next downtime.

The Authors

R. R. Warne

W. B. Black, Jr.

Robert R. Warne was graduated in both mechanical and civil engineering at Texas A&M College in June, 1941. Upon graduation he started work for Humble as a metal inspector. In 1948, he was transferred to the maintenance and construction department as a zone supervisor. He became zone supervisor in the central shop building in 1951, and acted as assistant employee relations manager in 1954. Warne is now zone supervisor in charge of maintenance of refinery cracking equipment.

W. B. Black, Jr., began work for Humble in 1934 in the pipe department, of which he became supervisor in 1942. He was made an assistant zone supervisor in the maintenance and construction division in 1947. Black is now assistant zone supervisor in that division, in charge of maintenance of fluid catalyst cracking units.

TABLE 1.
Turnaround Planning — Sequence of Events

CATALYTIC CRACKING UNITS WEEKS AFTER TURNAROUND		
Completion of Last Turnaround	→	0
Post-Turnaround Meeting	→	1
Service Factor Committee Reviews Preliminary Project List for Next Turnaround	→	4
Recommendations Prepared		8
Service Factor Committee Reviews Recommendations	→	11
Operating Management Requests Formal Estimate	→	12
Interim Period		
WEEKS BEFORE NEXT TURNAROUND		
Date of Preliminary Turnaround Meeting Scheduled	→	28
Dead Line for Submission of Work to Project Engineer	→	26
Preliminary Turnaround Meeting Held	→	24
All Engineering Complete	→	20
Service Factor Committee Reviews Work Schedule and "Bottleneck" Jobs	→	16
Date of Final Turnaround Meeting Scheduled	→	14
Report by Service Factor Committee Issued	→	13
Final Turnaround Meeting Held	→	12
Turnaround Supervisory Meetings	→	2
Start of Turnaround	→	0

* * *

This new American managed and operated refinery will supply most of that country's petroleum product needs

Iraq's First Daura Refinery

Dr. Nadhim Al-Pachachi, et al[1] and Staff[2]
Government Oil Refineries Administration, Baghdad

J. W. Mitchell, general manager of the new Iraq refining company, is well-known in this country, having had extensive refining experience prior to taking over the manufacturing system at Baghdad for the Iraq government a few years back, when the refinery was first begun.

Nadim Al-Pachachi

Ata Amin

Mohamed Al-Naqib

Ihsan Rifat

[1]H. E. Dr. Nadhim Al-Pachachi, minister of economics. H. E. Ata Amin, chairman of the board. Mohamed Al-Naquib, director-general of the board. Ihsan Rifat, chief of technical section and director general of oil affairs.

[2]Jefferson W. Mitchell, general manager Alfred R. Guest, assistant general manager. Melbourne G. Fryback, chief process engineer.

Design and operation of a refinery making products for the Near Eastern requirements must differ from that of a refinery for the European and Western World. The new state refinery in Iraq, designed, built and operated by American engineers, is planned to make more fuels for heating and lighting, less fuel for automotive (gasoline) engines; less attention is paid to octane number. This new plant is described here in detail, and its purpose, throughput, and quality and quantity of finished products shows what is required of a plant that is to meet the demands of the customers in an Asia Minor country.

ERECTION of a government oil refinery has been one of the aspirations of the national government since it was first instituted. The agreement between the Iraq Government and the Iraq Petroleum Company in 1931 referred to this aspiration to be realized by the company on the government account in a site to be stipulated later. It could not be realized, however, until 1955.

The Daura site, which in area for the equipment involved is the largest in the world, had been chosen by the Government of Iraq for three reasons: Its proximity to Baghdad; because the river provided easy transport, and because the water from the river could be used in the plant for cooling purposes.

Proximity to Baghdad is vital. The people of that city are the chief consumers of petroleum products in Iraq, using approximately 40 per cent of the country's consumption. Also, oil destined for other parts of the country can be best distributed from Baghdad. Not least in the considerations that influenced the choice of site was its communications with the city. For three routes now carry the products of the refinery to Baghdad: An oil pipe line system, the railway, and the barges on the Tigris. The pipe line to the city connects directly with the distributing center to the nation. A special jetty has been built for loading barges at the refinery.

The Baghdad refinery was built by Iraqi construction forces, with British engineering equipment and machinery all directed and welded together by American know-how. To provide foundations for the process units and all the heavy equipment required in the refinery, 4500 concrete piles were sunk, then materials and equipment of over 20,000 tons were imported.

More than 80 per cent of the 20,000 tons of machinery, apparatus and equipment has been provided by British manufacturers, with a few specialized items originating from the United States.

This was the work of a team. Some 3800 Iraqis were sought to form a giant labor force under the guidance of key British and American technical experts. Hundreds of Iraqis had to be trained as welders — men who previously had no experience with mechanical tools.

Wherever possible, maximum use was made of Iraqi materials, including 2,000,000 specially made bricks, and the cement used for foundations and roads all came from local sources.

With so large a refinery, quantities of steel piping and tubing were necessary for they make up between 20 and 25 per cent of the total material cost of a refinery. At Daura, 430,000 ft of steel piping and 50 miles of steel-wire armored cable were used, as well as 10 miles of copper-sheathed cable and 24 miles of vulcanized-rubber insulated cable in steel conduits.

To handle 20,000 tons of material on the site, special equipment was introduced. To set the steelwork into position, giant crawler-tracked cranes with 100-ft booms were employed. These cranes helped to lift the giant cranes whose job it was to install the highest towers and process units in position.

The crude petroleum for the Daura refinery is pumped through a specially built pipe line from the Iraq Petroleum Company's pumping station K-2 at Baiji, 130 miles NNW of Daura, into

storage tanks at the Baghdad refinery. There it is refined so that it can be separated into a variety of top-quality products — motor fuel, kerosine (lamp oil), gas oil, diesel oil and fuel oil. These are produced in the refinery to meet the ever growing needs of Iraq's industrial program.

Design and construction of the process units was by The M. W. Kellogg Company, concrete work was by D.&C. and William Press Company, Ltd., civil engineering was by Maunsel, Posford, Pavery Company, and power plant engineering by Cyanamid Products, Ltd.

The operations of crude distillation, visbreaking, cracking, reforming and vacuum flashing are carried out in a single integrated plant. Very considerable savings are effected in comparison with conventional plants — lower capital cost, reduced labor costs and a considerable saving in fuel, electric power, steam, and water. Labor costs are cut because of the high degree of automatic instrumentation incorporated in the design.

There is a power plant producing the very large quantities of steam and electric power needed for the processing operations. Large quantities of water, approximately 3000 imperial gallons per minute, to condense and cool the products as they come from the process units are pumped from the Tigris through treaters and filters. But before the water is returned to the river, it is purified to ensure that no harm can be done to fish or animal life.

The most modern welfare facilities have been provided to ensure ideal working conditions night and day. These include workshops, laboratories, change house, the canteen, garage and a medical center. Fifty staff houses and 200 worker homes are under construction.

'On Stream'

The culmination of the many months in constructing the refinery was reached on May 31, 1955, when crude oil was first charged to the Combination Unit. The unit was operated, beginning June 1, 1955, for two weeks and then shut down for a brief mechanical inspection to insure that there were no flaws in any of the equipment. On June 27, 1955, the Combination Unit came back on stream, and Iraq's new era of self-sufficiency in refining had really begun.

In this refinery, Iraq crude oil is being processed. Consumption of these products in Iraq has increased at a rapid pace, paralleling the economic revolution that a rapidly expanding oil production has brought to the country. In 1954, some 6,630,000 bbl of total products were consumed, representing a rise of about 60 per cent within the last five years, as shown in Table 1.

TABLE 1. Sales of Major Petroleum Products in Iraq 1950-1954 (Thousands of Barrels).

	1950	1951	1952	1953	1954
Motor fuel (gasoline)	723	795	851	991	1121
Kerosine	917	963	1038	1199	1407
Gas oil (high-grade diesel)	255	309	399	514	653
Fuel oil	2299	2729	2989	3290	3449
TOTAL	4194	4796	5277	5994	6630

Thus, Daura, with its design capacity of 24,000 BPSD or 8,760,000 bbl per year, has been designed to meet the requirements of an expanding economy.

Crude Supply

Crude comes from the Kirkuk fields some 180 miles north of the refinery. The plant was designed and has initially operated on stabilized full-range 36-deg API Kirkuk crude, which has a total sulfur content of 2.0 wt per cent. The government has a contract with the Iraq Petroluem Company for the production and export of Iraq crude oils and arrangements were, therefore, made with the Iraq Petroleum Company to supply crude to the refinery.

The crude is delivered through a 12-in. pipe line from the Iraq Petroleum Company's pumping station at Baiji, some 10 miles west of the Tigris and 130 miles NNW of Daura.

The pipe line crosses a flat route generally sloping downwards from Baiji to Baghdad. Approximately 45,000 B/D could be pumped through the line without exceeding the maximum permissible stress of the pipe line. Along the northern section of the route, the line crosses a slightly undulating gravel and sand plain. Along the rest of the route, the ground is relatively level plain, the pipe line crossing some cultivated and built-up areas. Main pipe line crossings include the Wadi Tharthar Flood Protection Scheme Channel and Al-Khir River.

For corrosion protection, the line is cathodically protected with two transformer rectifier systems — one at Baiji and the other at Kadhimain, 12 miles from Daura.

Operating Flexibility

Since the plant was designed to meet projected 1956-57 market require-

TABLE 2. Combination Unit Yields and Typical Product Inspections.

	BPSD	Liquid volume per cent of charge
Charge		
Stabilized full-range. Kirkuk crude	27,000	100.0
Products		
Motor fuel	6,129	22.7
Kerosine	5,643	20.9
Gas oil	3,807	14.1
Diesel	*	*
Fuel oil	9,342	34.6
Bunker "C" oil	1,053	3.9
Gas and loss	1,026	3.8
	27,000	100.0

* Fuel oil and gas oil are tank blended to make diesel oil according to market demand.

Typical Finished Product Inspections.

	Motor fuel	Kerosine	Gas oil	Diesel oil	Fuel oil	Bunker "C" oil
Gravity, deg API	68.1	47.5	37.4	29.2	20.3	11.9
Distillation:						
IBP	99	284	369	—	—	—
10 per cent	126	331	446	—	—	—
30 per cent	160	354	500	—	—	—
50 per cent	199	379	530	—	—	—
70 per cent	237	414	561	—	—	—
90 per cent	288	464	604	—	—	—
E.P.	338	504	644	—	—	—
Flash point, P-M, F	—	108	174	180	185	200+
Sulfur, weight per cent	.07	.10	1.0	2.0	3.5	4.4
Reid vapor pressure, psi	8.0	—	—	—	—	—
Viscosity:						
Redwood 1 at 100 F, sec.	—	—	35	57	200	—
Redwood 2 at 122 F, sec.	—	—	—	—	—	250
Pour point, deg F	—	—	10	20	25	75
Color	—	25 (Saybolt)	2.0 NPA	—	—	—
Carbon residue, weight per cent	—	—	.02	2.0	8.4	11.6
Diesel index	—	—	62	—	—	—
Octane:						
Motor	74	—	—	—	—	—
Research	78	—	—	—	—	—

ments, present demands require that the unit run at 75 per cent of design capacity, about 18,000 BPSD.

However, on August 24, 1955, a test run was initiated on the Combination Unit: The throughput was raised to 27,000 BPSD or 112.5 per cent of design capacity; unit performance was excellent. Yields for this period and typical product inspections are given in Table 2.

The Combination Unit has proved to be very flexible, easily adaptable to changes in operation. It is apparent from the market comparisons shown in Table 3 that the immediate problems were the sharply decreased current requirements for motor fuel and Bunker "C."

TABLE 3. Comparison of Current Sales Demand vs Design (As Per Cent of Crude Charge).

	Current	Design
Motor fuel	12.6	25.8
Kerosine	16.7	14.4
Gas oil	9.7	8.2
Diesel	15.2	12.2
Fuel oil	34.6	16.4
Bunker C" oil	0.6	15.1

The problem of excess heavy-residual fuel oil was solved by reducing gas oil cracking severity practically to the point of doing no cracking but merely passing gas oil through the cracking coils in the combination reforming-cracking furnace for protection of the tubes against overheating.

After considerable study of the problem of over production of motor fuel it was decided to "tailor" the crude at the producing field. In order not to completely lose the octane advantage of the light front end of the crude, only a portion of the crude is deep stabilized, removing the 1BP-350 F fraction. This fraction is then blended with full crude giving a resultant tailored crude containing approximately half as much straightrun motor naphtha but still retaining the entire boiling range of stabilized full crude. Table 4 compares the properties of the tailored and stabilized full crude.

TABLE. 4. Comparison of Tailored and Stabilized Fuel Kirkuk Crude.

	Tailored Kirkuk crude	Stabilizing full range Kirkuk crude
Deg API	30.6	36.2
Distillation:		
Per cent distilled at 250 F	4.4	12.0
Per cent distilled at 300 F	7.0	18.5
Per cent distilled at 350 F	11.5	24.0
Viscosity, centistokes at 100 F	—	4.4
Sulfur, weight per cent	2.2	2.0
Reid vapor pressure, psi	2.0	4.5

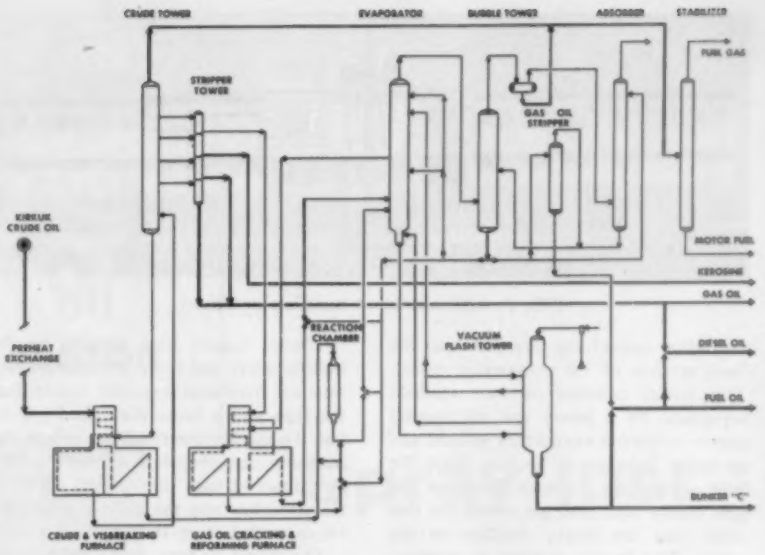


FIG. 1. Flow chart of the Daura refinery, Iraq.

Plant Description

The refinery has been designed to be entirely self-supporting. It supplies its own utilities, and there are complete facilities for plant maintenance, fire protection, and employee welfare such as canteen and a medical center. The major units that comprise the operational part of the refinery are: A combination thermal cracking plant, treating plant for both motor fuel and kerosine product, a power plant for the production of steam and electrical power, a river water plant for supply of raw river water to the refinery, a power plant for the production of steam and electrical power, a water treating plant for treating boiler-feed water and drinking water, a sulfuric acid plant to supply the acid for kerosine treating, and a can plant for the production and filling of 5 U.S. gallon cans.

Combination Unit

Within this single unit are integrated the following operations: Crude oil distillation, naphtha reforming, once-through visbreaking, heavy gas oil cracking, gas recovery, motor fuel stabilization and intermediate fractionation.

A simplified flow diagram for the unit is presented in Fig. 1.

The crude charge to the unit, after picking up preheat by exchange, enters the crude heating furnace. Here the crude is brought to approximately 630 F for vaporizing the required fraction of the crude before the stream is fed into the base of the crude tower. As an added means of control for degree of vaporization, stripping steam can be injected into the base of the tower.

In the crude tower, the crude is fractionated into a light straight-run naphtha overhead, four liquid side streams: Heavy straight-run naphtha, kerosine, light and heavy virgin gas oils, and a reduced crude bottoms stream comprising approximately 40 per cent of charge. The four liquid side streams pass on to the crude stripper tower where the front end properties are controlled by steam stripping.

The corrosive acidic elements passing overhead along with the light hydrocarbon vapors are neutralized by ammonia injection. The light straight-run naphtha overhead stream is fed to the stabilizer along with cracked motor fuel from the bubble tower overhead.

The heavy straight-run naphtha side stream is pumped to the reformer coil for octane up-grading. The stripped kerosine of 100-110 F flash point is cooled and delivered to intermediate storage before treating. The light and heavy gas oils are cooled and supplied in the required blending proportions to make gas oil and diesel oil.

From the bottom of the crude tower, the reduced crude is pumped to the visbreaking furnace for the required viscosity and pour point reduction.

To obtain added flexibility and control on the thermal severities, additional soaking time is available in a separate reaction chamber for visbreaking and gas oil cracking operations. To provide a better control of the reaction temperature and minimize the coke laydown, a cracked gas oil quench can be injected into the bottom of the reaction chamber, as well as to the individual effluent visbroken, reformate, and cracked gas oil streams.

These three furnace outlet streams containing gas, motor fuel, gas oil, and

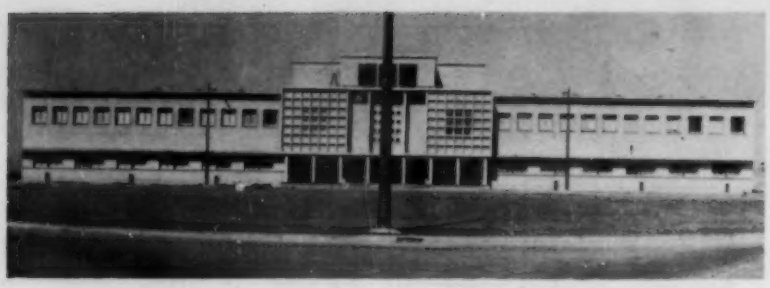


FIG. 2. Administration building at Daura.

tar, after quenching, are fed into the flash section of the evaporator tower. This tower consists of two sections separated by a heavy gas oil trapout pan — a bottom evaporator section and an upper light gas oil section. Here the first separation is made between the gas, motor fuel, and gas oil on the one hand and the heavy residue on the other. The heavy residue is pumped off the bottom to the vacuum flash tower for final removal of any light ends.

Liquid from the trapout pan constitutes the charge to the gas oil cracking coil. To insure that only clean vapors reach the trapout pan and thus prevent contamination of the charge to the cracking coils, several intermediate refluxes are used as safeguards. Their sources are the bubble tower bottoms stream of cracked gas oil and the light and heavy flash distillates off the circulating reflux streams at the vacuum flash tower. In the gas oil trapout pan, fractionating trays and stripping steam serve to prevent the inclusion of any light ends in the gas oil cracking charge.

The overhead from the evaporator, composed of gas, motor fuel, and light gas oil passes on to the bubble tower for additional fractionation. The heavy residue from the bottom of the evaporator is flashed in the vacuum flash tower to remove the last traces of the more valuable lighter components. The vacuum on the tower in maintained by a barometric condenser and three parallel sets of two-stage vacuum jets with inter and after condensers. Stripping steam can be introduced with the charge or directly to the tower bottom for additional stripping aid.

Vapors flashed off are condensed and separated into two fractions, a light flash distillate and a heavy flash distillate, which are sent back as circulating reflux and as intermediate reflux to the evaporator. The non-condensables and steam pass on overhead to the jets.

The vacuum flash tar bottoms are cooled and sent to tankage awaiting blending to a heavy residual fuel oil or Bunker "C" fuel.

From the evaporator tower, the overhead vapors pass directly to the bubble tower and there are fractionated into an overhead gas and motor fuel fraction and a bottom-cracked gas oil cut. To supply intermediate reflux, the bottoms are recycled as well as the combined stream of the rich oil from the absorber and the light cracked gas oil overhead from the gas oil stripper.

Overhead vapors from the bubble tower are partially condensed. The cracked motor fuel condensate joins with the light straight-run naphtha as charge to the stabilizer. Uncondensed vapors are fed to the absorber for recovery of the required amount of butanes needed for vapor pressure adjustment of the motor fuel. As in the case of the crude tower, ammonia is injected into the vapor overhead line for corrosion control.

The bottoms from the bubble tower, after exchange to provide the reboiler duty for the stabilizer, separates into many streams. Numbered among these streams are the charge to the gas oil product stripper, lean oil for the absorber, gland oil, flushing oils to instruments and valves, quenches, as well as the previously mentioned refluxes for the evaporator and bubble tower.

In the cracked gas oil stripper, the charge is steam-stripped over 4 trays for flash control of the heavy, cracked gas oil that is used as a blending stock.

The gas feed to the absorber is counter-currently extracted in a 30-tray column of the required butanes and heavier to meet vapor pressure requirements on the motor fuel. The unabsorbed gas passes out to the fuel gas system.

The combined stream of light straight-run naphtha and cracked motor fuel is fed to a 24-tray stabilizer. Motor fuel of the desired vapor pressure is pumped from the bottom to intermediate tankage before treating. Top reflux is provided from partial condensation of the overhead vapors. The uncondensed vapors are released to the fuel gas system.

Two floor-fired furnaces supply the crude preheat and the heat to the visbreaker, reformer, and cracking coils. Crude preheat and visbreaker coils are contained in one furnace while the second furnace houses the reforming and cracking coils. Both furnaces are equipped to burn either or both fuel gas and heavy residual fuel oil. The superheated low and high-pressure steam, 25 psi and 250 psi, required for all stripping come from separate coils installed in the convection section of the combination crude heating and visbreaking furnace. A blowdown and stack system takes care of oil and vapor disposal resulting from abnormal or emergency circumstances.

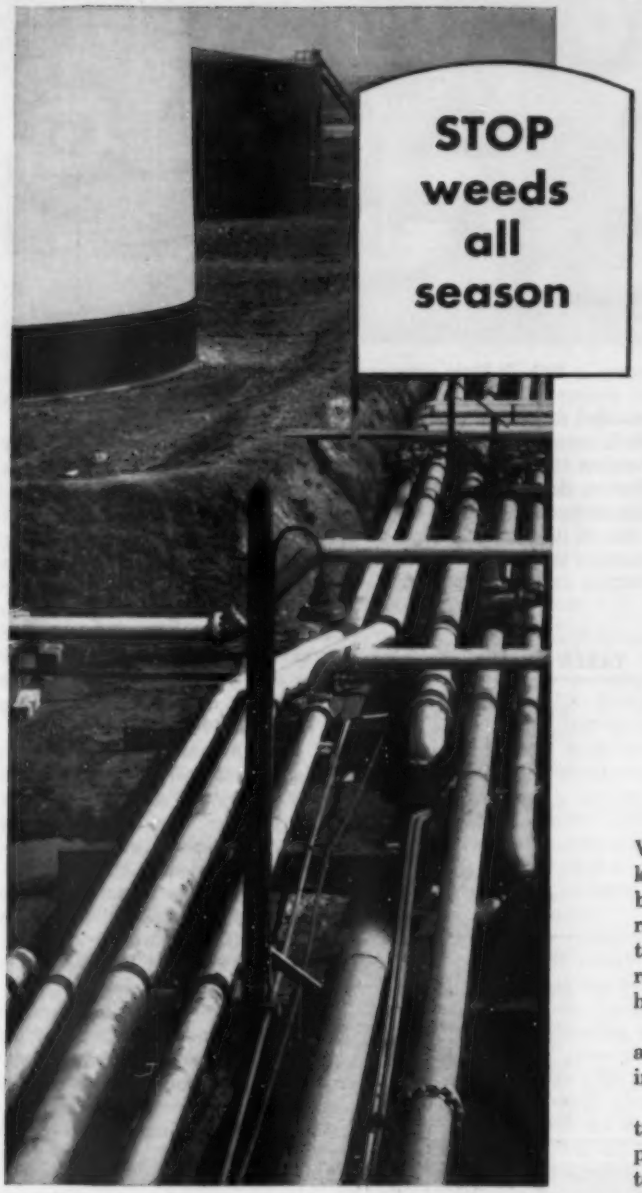
Motor Fuel Treating

The 6200 BPSD motor-fuel treating unit consists of caustic washing, regenerative caustic treating, copper sweetening and inhibitor and metal deactivator injection.

Removal of hydrogen sulfide is accomplished in the caustic wash section. The motor fuel is intimately mixed with a 10 per cent NaOH solution by passing the mixture through a mixing valve. The caustic and motor fuel are separated by gravity in a settling drum, and the motor fuel passes into the mercaptan extractor. The caustic is recirculated until it becomes spent, at which time it is withdrawn and the system is recharged with fresh caustic.

The motor fuel passing into the mercaptan extractor is contacted with a counter-current stream of caustic in a packed tower at a temperature of 100 F. The major portion of the mercaptans contained in the raw gasoline is taken up in the caustic solution. The motor fuel passes out the top of the extractor tower to a primary rock salt drier for removal of water, through a steam heater, and into the copper treating section. The caustic from the mercaptan extractor passes out the bottom, where it exchanges heat with caustic leaving the caustic stripper, through a steam heater, and into the top of the caustic stripper at a temperature of 240 F. The mercaptans are carried overhead by the stripping steam, through a condenser, where the steam is condensed, and into a separator. From the separator, the mercaptan vapors are piped to one of the burners in the crude preheat furnace for burning while the water is released to the sewer. The caustic leaving the bottom of the stripper exchanges with cold caustic coming into the stripper, passes through a water cooler, where it is cooled to 100 F, and into a storage tank, where it is ready for recirculation to the mercaptan extractor.

The motor fuel passes on to the copper sweetener where the remaining mercaptans are converted to disulfides by contact with copper chloride. The sweetened motor fuel passes out of the treating tower through a cooler and



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into a water settler for removal of the water produced in the reaction. From the settling drum, it passes through a secondary salt drier for removal of the last traces of moisture and then to treated fuel storage. Enroute to storage, small amounts of oxidation inhibitor and metal deactivator are injected into the gasoline stream to prevent oxidation in storage.

Kerosine Treating

The 4400 B/D kerosine treating unit consists of a sulfuric acid contacting section, a caustic neutralizing section, and a clay contacting section. The main function of the various sections is as follows:

(a) Acid treating: 98 per cent sulfuric acid is used to reduce the aromatic content of the raw kerosine and to reduce the quantity of sulfur present. The contacting is accomplished in two stages, and after the second contact and sludge separation by gravity settling, the sludge is pumped to the first stage contactor and the kerosine passed on to the acid coalescer tower. The coalescer is packed with a fiber glass and wool fiber packing.

(b) Caustic neutralization. As final insurance against the kerosine being acidic, it is pumped from the acid oil storage tank through a caustic-kerosine mixing valve and into a caustic settling tower. The kerosine flows overhead to a carbon raschig-ring packed caustic coalescer tower. The caustic is drawn from the bottom of the settling drum and recycled until approximately 75 per cent spent. The caustic level in the drum is then drawn down and 10 per cent NaOH and water added to achieve a fresh caustic strength in the drum of 6-7 per cent NaOH.

The unit possesses a clay contacting section for decolorizing. It consists of a clay storage hopper, elevator, clay-kerosine contactor, and sweetland filter. Kerosine leaving the caustic coalescer has been found to possess good color, and it has, therefore, been possible to by-pass the clay contacting step during current operation, thus achieving an appreciable saving in labor and clay costs.

Tankage

Within the refinery proper, tankage is provided for crude, intermediate, and product storage prior to pumping to the distribution facilities and can-filling sections for disposal. Auxiliary tankage is provided for such items as boilerhouse fuel, canning-plant charge tanks, and chemical storage.

The distribution depot adjacent to the refinery has storage facilities for all products. A list of the main tankage showing the number of days storage at desired production rates is shown in Table 5.

FIG. 3. Main entrance to Daura plant.

TABLE 5.

Material	Storage capacity (U. S. bbl)	Days storage at design production rate
Crude	428,000	18
Intermediate		
Motor fuel	54,000	8
Kerosine	36,650	10
Gas oil	5,450	4
Diesel oil	7,600	3
Fuel oil	21,000	3
Ethyl blending	76,000	
Work tanks	45,800	
TOTAL	256,500	
Product		
Motor fuel	272,000	40
Kerosine	170,000	38
Gas oil	170,000	43
Diesel oil	76,000	48
Fuel oil	230,000	35
Bunker C" oil	76,000	—
TOTAL	994,000	

Raw River Water Plant

Water is pumped from the River Tigris by two 175-hp electric pumps and delivered into two clariflocculators. Alum is added to the inlet stream to aid in flocculation. The clear water is then discharged into a four-section main reservoir of 3,000,000 gal capacity. The cooling tower pond provides secondary storage capacity of 760,000 gal. The silt from the clariflocculators is discharged back to the River Tigris. The average pumping rate from the river is 3000 gpm.

In order to prevent algae growth, chlorine, in the form of concentrated aquous solution, is added to both the water reservoir and cooling tower basin. The chlorine injection is semi-automatic, being controlled by a motorized valve in the water supply to the chlorine injection, the valve in turn being controlled by an electrically operated clock that can be adjusted to meet the refinery requirements.

Distribution of raw water throughout the plant and as make-up to the cooling water system is effected by two 2500 gpm motor-driven pumps with a turbine-driven pump as standby.

Three condensing turbine-driven

FIG. 4. Water pump house and cooling tower, serving entire establishment at Daura.

15,000 gpm cooling water pumps are provided for distribution of cooling water to the process units. Hot water from these units, together with that from the condensing turbines, is returned to the top of the cooling tower.

The cooling tower is of the all-film flow, induced-draught type, of reinforced concrete construction with a timber cooling grid system. The tower consists of five cells, open at the bottom for air intake and discharging into the cooling tower basin below. The basin is subdivided making it possible to use two, three, or five cells as required. Air flow is induced through the system of 20 13-ft diam fans, 4 per cell, located at the top of the cells. The tower capacity is 30,000 gpm under design conditions.

Power Plant

Four boilers, each of 75,000 lb per hour capacity, generate steam at 265 psi and 500 F. The boilers are outdoor type, and the flue gases discharge into two self-supporting brick-lined chimneys, 125 ft high. The boilers have no induced draft, and, in consequence, the combustion chambers are under pressure. Refinery Bunker "C" Oil, gas oil, and fuel gas are used exclusively as boiler fuel.

Water from the raw water plant is lime softened and filtered in a 20,000 gph treating plant. Condensate is deaerated and returned to the boiler feed water system.

Three condensing turbo-alternators of 2000-kw capacity and generating at 3300 v, 50 cycles, supply five high-tension substations. The alternator speed is 1500 rpm and the turbine speed is 6000 rpm. The low-tension net work is supplied at 380 v three-phase for power and 230 v for lighting. A standby diesel-alternator generating at 3300 v is available for cold startup of the power plant.

The plant 3300-v switch gear is either remote or manually operated and the bus bars are compound filled. Each section of bus-bars is housed in separate rooms with fireproof doors and is further protected by an automatic carbon dioxide fire-fighting system.

Compressed air is supplied at 100 psi by three motor-driven compressors. All of the air is filtered and approximately 200 cfm of instrument air is also dried. The drinking water for the plant is purified by pressure filtering and chlorinating. A 15,000-gal storage tank is provided, mounted on a structure 80 ft in height. The plant has a capacity of about 900 gpm.

Can Manufacturing and Can Filling Plant

Complete facilities are provided for the manufacture, from tin plate sheet stock, of standard 5 U.S. gallon square cans, warehousing finished cans and filling cans.

Currently about 170,000 cans per month or slightly over 2,000,000 cans per year of product are being shipped from the refinery. The largest single-product volume handled is motor fuel, for distribution to the remote parts of the country.

The plant has the capacity to manufacture 12,000 to 15,000 cans in 8 hr. Storage space is provided for 50,000 finished cans and 60,000 filled cans. Fork lift trucks capable of handling 90 cans per pallet are used.

For protection against explosive vapor concentration in the can-filling room, air change is provided by a building blower system and vapor pull-off at the nozzles of the filling machines. Any spillage is collected in catch trays situated beneath each filling machine and piped to the oily water sewer. A fog-head sprinkler system is incorporated in the roof of the building and in the filled can warehouse.

Sulfuric Acid Plant

The "Chemico" Process sulfuric acid plant is of the contact type, using vanadium pentoxide as a catalyst for the conversion of sulfur dioxide to sulfur trioxide. The plant is so arranged that sulfuric acid may be produced from burning raw sulfur and/or by recovery from acid sludge. Approximately 18 tons per day of 98 per cent acid can be produced from burning sulfur, and it is expected that some 7 tons per day will be produced from the sludge recovery section.

The sludge decomposition unit consists of a horizontal, rotary coke-heating kiln, a rotary sludge-decomposing kiln and facilities for circulating and storing coke. The heating kiln is fed continuously with coke produced in the decomposer. The coke is heated in the kiln to about 900 F, after which it flows by gravity into the decomposer. The coke is returned to the feed end of the heating kiln via a vibrating conveyor, bucket elevator, storage bin, and feeder unit.

By the action of the hot coke on sludge in the decomposer kiln, an impure high strength SO_2 gas is produced that contains coke dust, tar, steam, hydrocarbon vapors and small amounts of CO_2, O_2 and N_2.

After purification, the gases still contain non-condensable hydrocarbons that would be deterimental to the catalyst if allowed to reach the converter. Therefore, the gases pass through the SO_2 furnace. Leaving this furnace, the gases are cooled, first in an air cooler and then by direct-contact water spray in the cooling tower. The gas temperature in this tower must be reduced so that the moisture content of the saturated gases is below the water quantity required for the manufacture of the desired acid.

The gases from the cooling tower contain a small amount of acid as a fine mist, which is removed by means of an electrostatic precipitator. They then pass through a drying tower, where 93 per cent acid is used for drying, and hence through shell and tube heat exchangers where the temperature is elevated to about 800 F by exchange with converter outlet gases.

The SO_2 gas is contacted with vanadium catalyst in a four-stage converter at about 790 F and finally absorption of the SO_3 in the 98 per cent acid absorption tower.

For operation as a "dry" plant, there are facilities for the melting, filtering, and pumping of molten sulfur to the SO_2 furnace.

Fire Protection System

The refinery is laid out in a block system, with main roads and auxiliary fire roads to provide access to any unit from two or more directions. Space is provided between units to reduce the likelihood of fire spreading from one unit to another. All storage tanks are diked.

Main fire fighting equipment is carried by a fire truck and trailer, kept at the main fire station. There are five auxiliary fire houses at strategic locations throughout the plant.

A fire alarm system, built into the plant telephone exchange, indicates the point of origin of an alarm on a light panel in the main fire station.

A regular fire crew of four men per shift is maintained at the main fire station.

Water is taken from the raw water reservoir by two 2000-gpm pumps at a pressure of 150 psi. One pump is electrically driven, the other steam-turbine drive, to ensure against electrical failure. The refinery maintains a minimum inventory of 28 tons of foamite, of the single-powder type.

In the tank farm, cone-roof tanks used for storing volatile liquids are fitted with fixed foam chambers, with pipe lines terminating outside the tank dikes. Portable foam pourers are provided for use on floating-roof tanks, or those cone-roof tanks that do not have fixed foam connections.

The river loading jetty has two tower-mounted monitors, which may be supplied with water or foam. The Ethyl Blending Plant is protected by a fixed foam installation; the building also has a sprinkler nozzle system.

Process units, all pump houses and loading racks are provided with snuffing steam and portable foam equipment. Portable carbon dioxide

equipment is also provided where necessary for electrical fires.

Safety Stressed

To establish the rules and to inspect equipment for insurance against failure, a combined mechanical inspection and safety department has been established. Primary purpose of the department is to anticipate and prevent accidents and equipment failures that would endanger personnel or interrupt production.

To aid in locating and controlling hazardous conditions, at Daura all work outside the shops requires a written permit. The safety department makes tests for inflammable gases, and may specify precautions over and above the regular safety rules.

Employee Welfare

The most modern facilities have been planned to insure ideal working conditions for the employees.

An elaborate change house has been provided with wash rooms and lockers. A canteen will be commissioned in the near future.

A medical center has been established consisting of a plant physician and four dressers or nurses. Periodic checks are made on the health of the refinery personnel.

Fifty modern staff houses are nearing completion and construction has started on 200 houses for the workers. Ultimately the area will be equipped with parks, playgrounds, an athletic field, and a cinema. It is also planned that a shopping center will be erected in the vicinity by private interests.

Looking to the Future . . .

The Government Oil Refineries Administration, recognizing the steadily increasing demand for higher quality motor fuels, has already announced that the octane of the country's motor fuel will be raised from its present level to 80 research octane number. Careful consideration is being given to the possible addition of a catalytic reforming unit as a source for future additional upgrading of motor fuel quality. The present plant plot plan is arranged so that new processing units, storage tanks, and related equipment can be easily added.

A lubricating oil plant is already in the initial stages of construction to be located on the south side of the refinery. Foster-Wheeler, Ltd., of London, is the contractor for this plant, which will produce 500 B/D of high-quality lube oils. ★ ★ ★

Analytical Methods

P 205.

Analysis of Mono-and Di-sulfides in Gasoline

Charles W. Rippie
Electric Process Company

PHENYLENEDIAMINE inhibitor sweetening of catalytic-cracked sour gasolines oxidizes the mercaptan sulfur compounds to disulfide sulfur compounds. These sulfur compounds remain in treated gasoline. Disulfide sulfur compounds reduced the tetraethyl lead efficiency in the treated gasoline according to Lovell.[1] In order to evaluate the overall treating costs of PDA inhibitor sweetening, we have revised the Sigga-Edsberg[2] analysis of monosulfides and disulfides in gasoline.

Method of Analysis

Our revised procedure uses an aqueous bromate solution to oxidize monosulfides and disulfides in an alcoholic acid solution.

1. Add 1 ml or less gasoline sample, 10 ml ethyl alcohol, 2 drops methyl orange solution, and 5 ml concentrated hydrochloric acid in 125 ml glass stoppered flask.
2. Titrate with standard potassium bromate solution dropwise, until the first excess of bromate solution oxidizes the methyl orange to a colorless solution. Stopper the flask, shake one-half minute, add 1 drop methyl orange solution, and shake 20 sec to insure that a slight excess of bromate solution is present. If the solution does not become colorless, continue this procedure until the additional drop of methyl orange indicator is oxidized to a colorless solution. Keep $KBrO_3$ less than 10 ml.
3. Add 5 ml 5 per cent potassium iodide, stopper and shake, and add 50 ml of distilled water.
4. Titrate the liberated iodine with standard tenth normal sodium thiosulfate solution using starch indicator.
5. Determine the ml of potassium bromate in blank using exact amounts of all reagents without the gasoline sample according to the above procedure.

Reagents

0.100 N $KBrO_3$. Dissolve 2.76 g potassium bromate and 15.0 g potassium bromide in 1.01 distilled water.

Calculations

$$\text{Per cent wt } S/R_2S = \frac{\text{Ml } KBrO_3 \text{ blank} - KBrO_3 \text{ sample} \times \text{normality } KBrO_3 \times 0.16}{\text{Ml of sample} \times \text{specific gravity}}$$

$$\text{Per cent wt } S/R_2S_2 = \frac{\text{Ml } KBrO_3 \text{ blank} - KBrO_3 \text{ sample} \times \text{normality } KBrO_3 \times 0.64}{\text{Ml of sample} \times \text{specific gravity}}$$

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1. "Road Effectiveness of Tetraethyl Lead as Influenced by Added Sulfur," 15th mid-year meeting of the American Petroleum Institute's Division of Refining, May 4, 1950.
2. Analytical Chemistry 20, 988 (1948).

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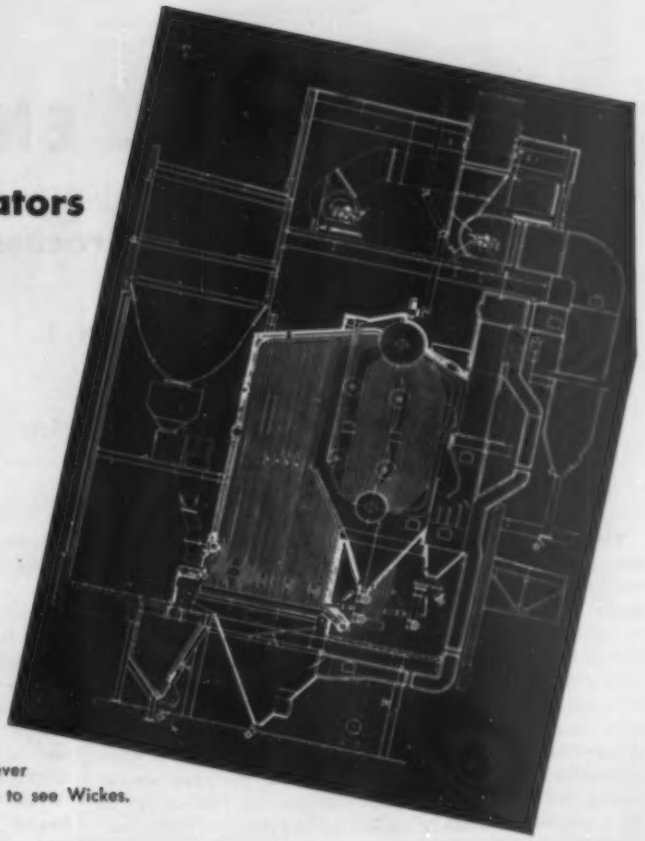

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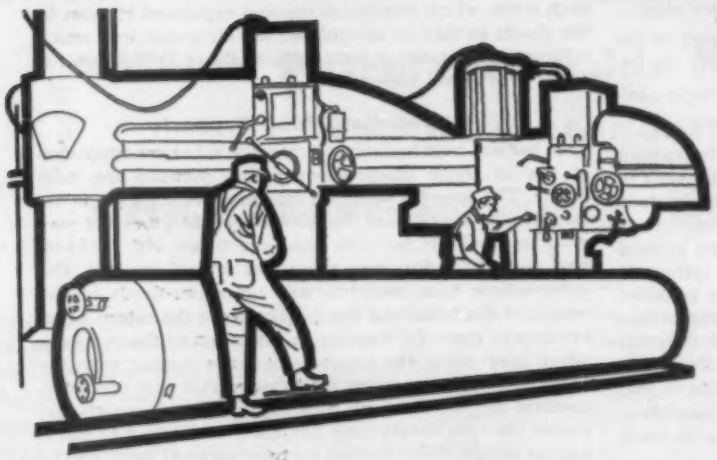

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P 734.1

MECHANICAL ENGINEERING

Mechanical Design of Processed Tubular Heaters

Part 2.

L. A. Mekler
Consulting Engineer

Header Compartments and Tube Sheets

The header compartments are box-type openings in the setting with doors on the outside for access to the headers and tube sheets on the furnace side. Except for the tube sheets, the header compartments are quite similar in design for all types of heaters. The tube sheets in all types of heaters serve primarily as membranes between the header compartment and the interior of the heater. In heaters with horizontal tubes, the tube sheets also act as end-tube supports designed strong enough to support the total weight of tubes and headers as if the intermediate supports were inoperative. With vertical tubes, one of the tube sheets, usually the one on the bottom, carries the full weight of the tubes and headers while the other tube sheet acts only as a separating membrane.

There are three types of construction of tube sheets:

1. Low-alloy cast iron, insulated on the furnace side.
2. Austenetic-alloy steel, usually 25-12, insulated on the header box side.
3. Uninsulated low-alloy cast iron or austenetic-alloy steel.

Type 1 is the most common construction for the radiant banks and the upper portions of the convection banks in heaters with horizontal tubes and for the top tube sheets in heaters with vertical tubes where the hot face temperature of the sheets is above 1200 F, as in heater J. The present trend is to use prefired, preshaped insulating refractory shapes bolted to the casing instead of poured on gunnited castables, particularly if the ribbing on the casting breaks up the insulation into a large number of small irregular shapes. There is an appreciable difference in the coefficients of expansion of the insulation and the casting so that the ribs have a tendency to pull away from the insulation, or, if the insulation adheres strongly to the ribs, to crack the castable between the ribs.

Type 2 construction is used primarily in the radiant sections and the hot portions of the convection sections of heaters G and L where the radiant tubes are hung from the top or are supported on column-like members from the bottom, to maintain the tube sheets at substantially the same temperature as the intermediate supports. Otherwise, the differential expansion between the tube sheets or the intermediate tube supports will make the tube sheets or the intermediate supports inoperative as supporting members and cause bowing or sagging of the tubes.

Type 3 construction with alloy-steel tube sheets is used on multirow tube banks with close tube spacing, such as radiant soaking banks and the upper portion of convection banks, where the small spaces between the ribs of a low-alloy cast iron sheet may make Type 1 construction expensive or unreliable. Generally, with uninsulated high-alloy tube sheets, the sides and the doors of the header compartment must be better insulated than with Type 1 construction.

Uninsulated low-alloy cast iron is used for tube sheets exposed to temperatures below 1200 F on the hot face, such as the lower portion of the tube sheets of convection banks with horizontal tubes and the top tube sheets of radiant bank in heater K and of the convection bank in heater J. In heater K, the tubes are supported on the bottom so that the top tube sheets act as an unloaded membrane. Also, in this heater, the tube sheets are made of small over-lapping segments free to slide with respect to each other, which eliminates thermal expansion stresses in the sheets so that an uninsulated low-alloy cast iron which is structurally stable at temperatures above 1200 F is satisfactory for these tube sheets.

Intermediate Tube Supports

In heaters with horizontal tubes, the tubes are supported at one or more intermediate points between the tube sheets. The span between the intermediate supports is determined by the OD and the thickness of the tubes and may vary from 4½ ft for 2-in. pipe size tubes with 0.154-in. wall, to 9 ft for 8-in. pipe size tubes with ½ in. wall. The intermediate tube supports will carry two-thirds of the weight of the tubes and the fluid between the return headers to take care of difference in expansion of the supports, which may cause the supports to loose contact with the tubes or may push against the tubes so that only one intermediate support and both tube sheets or two supports and one of the tube sheets carry the load. In addition to carrying the weight, the intermediate tube supports must also be able to withstand side thrust due to friction between the tubes and the support as the tubes expand length-wise or bow sidewise.

The intermediate tube supports are made of austenitic 25-12 cast alloy in the radiant section and the hottest rows of the shock bank and the convection bank, and of low-alloy cast iron in the portions of the convection bank where the metal temperature is below 1200 F. The supports for the wall tubes in the radiant section are usually made as brackets, which extend through the lining and are supported by the structural steel. Radiant-roof tube supports are made as clusters, or T-bar sections hung from the structural members of the roof. Convection-bank tubes supports

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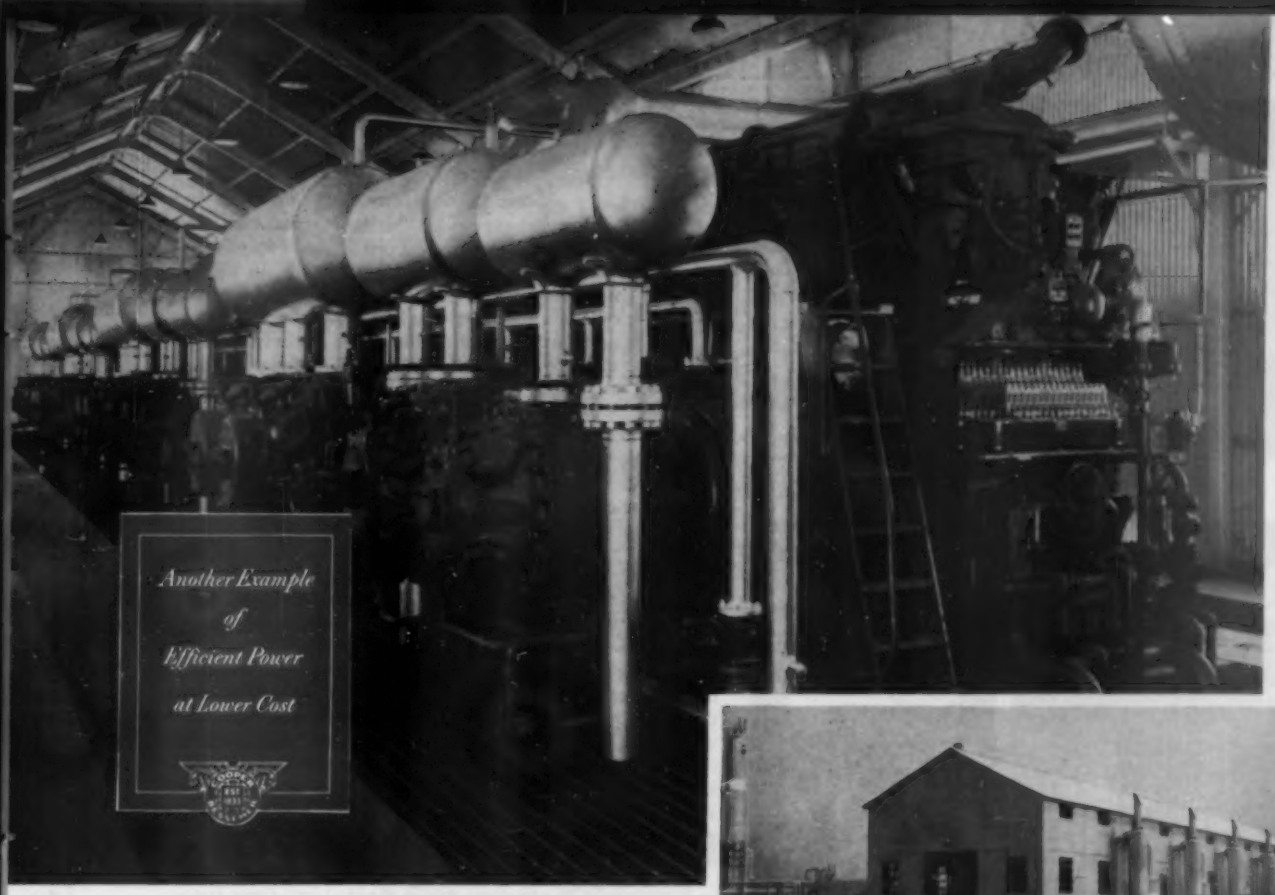

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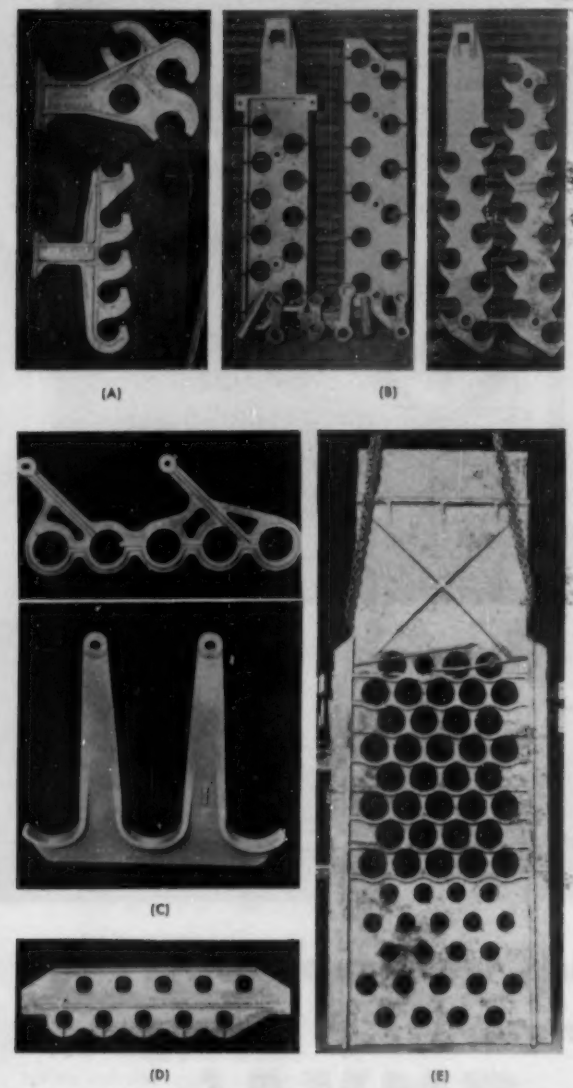

FIG. 3. Austenitic alloy tube sheets and intermediate tube supports:

(A) Intermediate, side wall, single and double row; (B) tube sheets and intermediate for Heater G; (C) single-row roof intermediate (courtesy The Colorizing Co. and Ohio State Foundries); (D) intermediate, shock or roof tubes; (E) connection tube sheets.

are usually made as ribbed sheets hung from the top and tied into the structural members of the sides of the convection bank against lateral movement, as in heaters B, D, E, F, and L, or supported from the bottom or the sides, as in heaters A, and G. Fig. 3 shows the various types of end-tube sheets and intermediate supports.

In heaters with vertical tubes, no intermediate supports are used. Instead, the tubes are provided with tube guides on the back of the tubes, which hold the tubes against bowing inward toward the heat or sideways towards adjoining tubes and acts as spacers between the back of the tubes and the face of the lining. Normally, the guide plates are subjected to low stresses, and since they are on the shielded half of the tube and are oil cooled, they are usually made of the same material as the tubes. However, if, because of improper installation of the heater or the piping, the tubes are restrained from free expansion by binding in the tube sheets or by stiff inlet and inlet or outlet piping, the tubes may exert sufficient stresses on the guides to break them, no matter what material is used for the guides.

The Coil

The coil of a process heater is the most important and usually the most expensive of the four structural components of the heater. Usually, the coil is made up of tubes connected in series by headers or return bends. In heaters of some catalytic processes, where the heater tubes are filled with catalyst, the tubes are in parallel between common inlet and outlet headers, but these heaters, usually referred to as "fired reactors," are the exception rather than the rule.

There are two methods of joining the tubes and headers —rolling and welding. With single-row tube banks, or with tubes in double rows on wide spacing, where a satisfactory weld can be made along the full circumference of the tube, the tendency is towards welding. With multi-row banks, rolled joints are used. Where the charge tends to permeate the metal and leak through fissures of even capillary size, rolling, if used, is supplemented by seal welding around the end of the tubes on the inside of the fitting.

Main advantage of welding is that, when properly made, it gives a strong and leak-proof joint. However, with steels containing more than 1¼ per cent chrome, the welds require annealing for stress relieving. With shop-fabricated coils, the whole coil is usually stress relieved. With field welds, the weld and the "heat escapement zone," 6-10 in. on both sides of the weld, is locally annealed to restore the strength and particularly the corrosion resistance of the weld and the adjoining metal. Seal welding, which is usually applied in a number of small beads, does not require stress annealing.

Structurally, the headers can be divided into three types: (1) Clean-out headers with individual plugs for each tube; (2) Y headers with one plug in the leg of the Y that can be used for clean out; (3) blind U bends without clean-out plugs.

Clean out headers can be used with rolled or welded joints, while only welding can be used with the other two types.

Fig. 4 shows principal types of headers used in process heaters.

In the last few years, steam and air decoking has been replacing turbining for removing coke deposits on the inside of the tubes. With steam and air decoking, clean-out plugs are not only unnecessary but are often undersirable because headers with plugs are often hard to decoke, particularly around the plug hole, and with imperfect rolls, the rolls tend to leak and plugs may have to be retightened after each decoking. The leaks are due not to weakening of the metal, but to originally imperfect rolls and plug assembly that were sealed by coke deposits. Decoking burns out the coke seals.

On processes where the coke deposits can be easily removed by steam and air decoking, blind U bends are used throughout the coil except for a few tubes where a single plug header is used on both ends of a few tubes for corrosion inspection and to check whether the coil is totally decoked. With vertical tube banks, where the tube bank is cleaned by turbining or where steam and air decoking does not always result in a perfect clean out, two-plug return bends with rolled or welded joints are usually used on the top and a welded Y fitting on the bottom. The plugs in the top return bends permit turbining of any tube or using any tube for checking the results of steam and air decoking.

One of the hardest tasks of the mechanical designer of process heaters is the selection of proper metals for the coil, particularly for the tubes. To begin with, the metal

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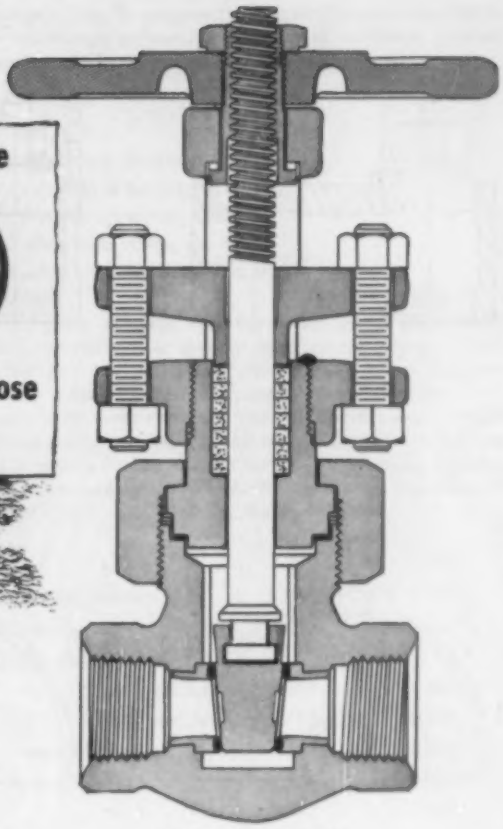

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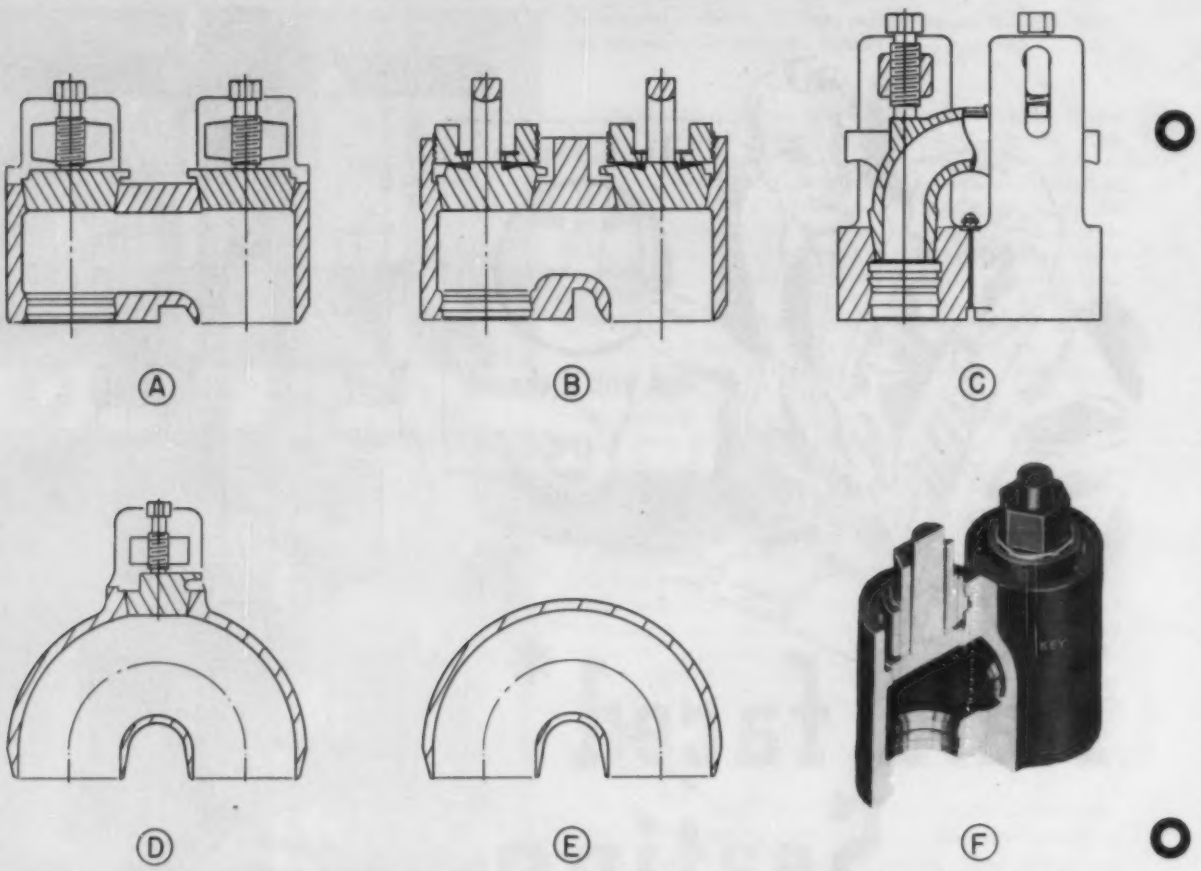

FIG. 4. Principal types of headers: (A) Mule-ear closure; (B) bull-plug closure; (C) streamline sectional; (D) Y fitting; (E) blind U-bend; (F) modified bull plug. A and B, RH for rolling, LH for welding. — Courtesy Key Co.

selected must be strong enough to withstand the stresses due to internal pressure. While there are no rigid limitations on tube thickness, it is desirable that with the maximum thicknesses of the tubes the ratio of outside to inside diameter is less than 1.2, without corrosion allowance, and not more than 1.3 with corrosion allowance. With these ratios, the tubes can be considered as thin wall cylinders in which the hoop stresses due to internal pressure are dominating, so that the longitudinal stresses can be neglected in the calculations. Also, in thick wall tubes, especially if made of austenetic alloys, the thermal stresses due to differential expansion between the fibres on the outer and inner surface of the tubes may become significant. In thin wall tubes, the highest thermal stresses, produced at the maximum heat-transfer rates obtained in well designed heaters, normally are relieved by a small amount of plastic flow, so that they can be neglected in the calculations.

Most process heaters operate for long periods with tube metal temperatures at which the creep strength and stress to rupture rather than the short-time mechanical properties are used to determine the strength and the useful life of the tubes. The creep strength is the stress, in psi, which will produce at the selected temperature a certain elongation, or creep, during a specified time interval. Most commonly used values for creep strength are the stresses that will produce a creep of 1 per cent in 10,000 hr or in 100,000 hr, usually expressed as 0.1 per cent in 1000 hr and 0.01 per cent in 1000 hr. Many of the accepted values for creep at 10,000 hr and almost all values for 100,000 hr are extrapolated from tests of shorter durations. The stress to rupture is the stress, in psi, that will produce a rupture at the specified temperature in a definite period of time, such as 10,000 hr or 100,000 hr. As with creep, the stress to rupture values, particularly those for 100,000 hr, are also extrapolated from tests for shorter periods. Table 3 gives the composition and high-temperature properties of the alloys most commonly used for the coils of process heaters.

There is no definite relationship between creep strength or stress to rupture of different alloys through the same range of temperature or of the same alloys at different temperatures. For example, with Carbon-Mo steel, the ratio of rupture strength to creep strength at 900 F is approximately 1.6 for 10,000 hr and approximately 1.27 for 100,000 hr, while at 1000 F and 100,000 hr it is appromixately 1.83. With 5 chrome at 1000 F and 100,000 hr, the ratio is approximately 1.4. The two sets of data, however, can be coordinated to estimate the life expectancy of a tube designed for a given creep strength or to select a creep strength for the desired life expectancy with more assurance than by the use of creep strength or stress to rupture alone.

There are a number of formulas available for determining the principal stresses in the tubes of a coil subjected to internal pressure. The most commonly used are:

1. Modified Lame, where the tangential stress at the inner surface is the maximum principal elastic stress

$$\partial_t = p\left[\frac{1}{2}\left(\frac{D}{t}\right) - 0.4\right] \quad . \quad . \quad . \quad . \quad (1)$$

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2. Clavarino, based on an "equivalent" stress at the inner surface, derived from the maximum *strain* criterion of failure, elastic stress distribution and a Poisson's ratio of 0.3.

$$\partial_t = p\left[\frac{0.425\left(\frac{D}{t}\right)^2 - 0.4\left(\frac{D}{t}\right) + 0.4}{\left(\frac{D}{t} - 1\right)}\right] \quad . \quad . \quad (2)$$

3. Bailey-Nadai, based on the equivalent stress either at the inner or at the outer surface, maximum *sheer* criterion of failure, plastic stress distribution and a power function, n, in the stress-strain diagram.

$$\partial_{eq} = p\left[\frac{\beta}{1-\left(\frac{d}{D}\right)^{\beta}}\right] \quad . \quad . \quad . \quad . \quad (3a)$$

$$\partial_{eq} = p\left[\frac{\beta}{\left(\frac{D}{d}\right)^{\beta}-1}\right] \quad . \quad . \quad . \quad . \quad (3b)$$

4. Creep-Common, an empirical formula, based on stresses intermediate between outer and inner surface stresses.

$$\partial = p\left[1/2\left(\frac{D}{t}\right) - 0.7\right] \quad . \quad . \quad . \quad . \quad (4)$$

5. On the basis of work by a special task force of the ASA, the ASME boiler code has suggested a general formula,

$$\partial = p\left[1/2\left(\frac{D}{t}\right) - y\right] \quad . \quad . \quad . \quad . \quad (5)$$

where y is a factor varying from 0.4 to 0.7 depending on the temperature. Transposed, this formula gives the following relationships between the minimum thickness, internal pressure, outside diameter and allowable stress:

$$t = \frac{pD}{2S + 2yp} + C$$

t = minimum thickness, inches
= internal pressure psi,
D = outside diameter, inches
S = allowable stress, psi
C = allowance for corrosion, inches

The allowable stresses and the y values in the ASME formula are for *piping* usually designed on a basis of 20-year life and are, therefore, more conservative than required for a maximum life of tubes in process heaters.

There is little difference in the numerical values for the dominant stresses calculated by the different formulas, except Clavarino, for the thinner tubes. For example, with an internal pressure of 1000 psi, the calculated stresses for tubes with D/t of 10 and 20, are as follows:

D/t	10	20
Modified Lame	4,600	9,600
Clavarino	4,322	8,547
Baily-Nadai		
(n = 5 inner surface)	4,684	9,693
(n = 5 outer surface)	4,284	9,294
Creep-Common	4,300	9,300
General y = 5	4,500	9,500
y = 7	4,300	9,300

Therefore, with a given internal pressure, all of these formulas will give substantially the same wall thickness.

Generally, the coil of a heater is seldom designed for a useful life of more than 10 years, or approximately 80,000 operating hours. Also, during the useful life of the heater, the deformation or creep can be more than 1 per cent. Therefore, using the stress for 1 per cent creep in 100,000

TABLE 3. Condensed data of more common steels and alloys used in coils of process heaters.

		Carbon Steel (Killed)		Carbon Molybdenum Steel		1¼ Chr. Molybdenum		2¼ Chr. Molybdenum		5 Chrome		5 Chrome Silicon		7 Chrome		9 Chrome		18-8		25-12		25-20	
ANALYSES per cent	Carbon	0.10-0.20		0.10-0.20		0.15 Max.		0.15 Max.		0.15 Max.		0.15 Max.		0.15 Max.		0.15 Max.		0.08 Max.		0.20 Max.		0.15 Max.	
	Manganese	0.30-0.80		0.30-0.80		0.30-0.60		0.30-0.60		0.30-0.60		0.30-0.60		0.30-0.60		0.30-0.60		2.00 Max.		2.00 Max.		2.00 Max.	
	Sulphur	0.058 Max.		0.045 Max.		0.030 Max.		0.030 Max.		0.030 Max.		0.030 Max.		0.030 Max.		0.030 Max.		0.030 Max.		0.30 Max.		0.030 Max.	
	Phosphorus	0.048 Max.		0.045 Max.		0.030 Max.		0.030 Max.		0.030 Max.		0.030 Max.		0.030 Max.		0.030 Max.		0.030 Max.		0.35 Max.		0.030 Max.	
	Silicon	0.25 Max.		0.10-0.50		0.50-1.00		0.50 Max.		0.50 Max.		1.00-2.00		0.50-1.00		0.25-1.00		0.75 Max.		3.50 Max.		0.75 Max.	
	Chromium	—		—		1.00-1.50		1.90-2.60		4.00-6.00		4.00-6.00		6.00-8.00		8.00-10.00		18.00-20.00		22-24		24.00-26.00	
	Nickel	—		—		—		—		—		—		—		—		8.00-11.00		12-15		19.00-22.00	
	Molybdenum	—		0.45-0.66		0.45-0.66		0.87-1.13		0.45-0.65		0.45-0.65		0.45-0.65		0.90-1.00		—		—		—	
CREEP STRENGTH	Temp. F	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)
	800	19,500	13,500	33,500	23,500	—	—	—	—	—	—	—	—	—	—	—	—	—	20,300	—	—	—	—
Stress (psi) for 1%	900	11,000	8,400	24,500	17,200	35,000	20,000	40,500	22,000	17,900	15,000	—	—	14,500	9,200	33,250	24,750	24,000	18,000	23,000	15,000	—	—
elong.	1,000	7,200	2,150	12,400	5,200	14,700	8,200	16,350	7,600	9,200	7,300	8,200	5,700	8,000	5,000	12,000	8,500	18,300	11,500	16,500	10,500	—	—
[(A) 10,000 hr	1,100	—	—	—	—	5,500	2,125	9,200	4,910	4,800	2,400	4,400	2,700	4,400	2,500	6,950	3,775	11,550	7,100	11,000	7,000	—	—
(0.10%/1000 hr)	1,200	—	—	—	—	3,375	910	4,175	2,510	1,800	900	1,600	850	2,000	1,300	2,300	1,600	6,600	4,250	7,000	4,500	7,400	5,400
(B) 100,000 hr	1,350	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2,500	1,600	3,000	1,800	3,300	2,800
(0.01%/1000 hr)	1,500	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1,000	—	1,100	800
RUPTURE STRENGTH	Temp. F	(C)	(D)	(C)	(D)	(C)	(D)	(C)	(D)	(C)	(D)	(C)	(D)	(C)	(D)	(C)	(D)	(C)	(D)	(C)	(D)	(C)	(D)
	800	21,000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	900	13,500	11,000	39,000	30,000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Stress for Rupture	1,000	7,000	5,000	16,000	9,500	20,500	10,500	19,000	14,000	14,500	10,000	11,200	8,000	—	—	—	—	—	—	—	—	—	—
(C) 10,000 hr	1,100	3,500	1,800	5,000	2,500	10,000	6,000	11,000	9,000	8,000	6,000	7,000	5,000	11,000	8,400	14,000	12,000	17,000	13,000	—	—	—	—
(D) 100,000 hr	1,200	—	—	3,000	1,800	4,000	2,200	6,000	4,000	4,500	2,100	4,000	3,000	5,000	3,500	6,000	4,500	10,500	8,000	14,500	10,000	8,500	5,000
(Interpolated)	1,300	—	—	—	—	—	—	2,500	1,600	2,500	1,300	1,800	—	2,500	1,200	2,500	1,200	6,000	4,000	7,000	4,000	5,000	3,000
										—	—	—	—	—	—	—	—	3,800	2,500	4,000	2,100	3,000	1,600
										—	—	—	—	—	—	—	—	2,500	2,000	2,500	1,200	1,800	—
OXIDATION RESISTANCE																							
Max. temp. limit, deg. F, for long life under oxidising conditions.		1,050		1,050		1,100		1,175		1,200		1,200		1,250		1,300		1,600		1,800		2,100	

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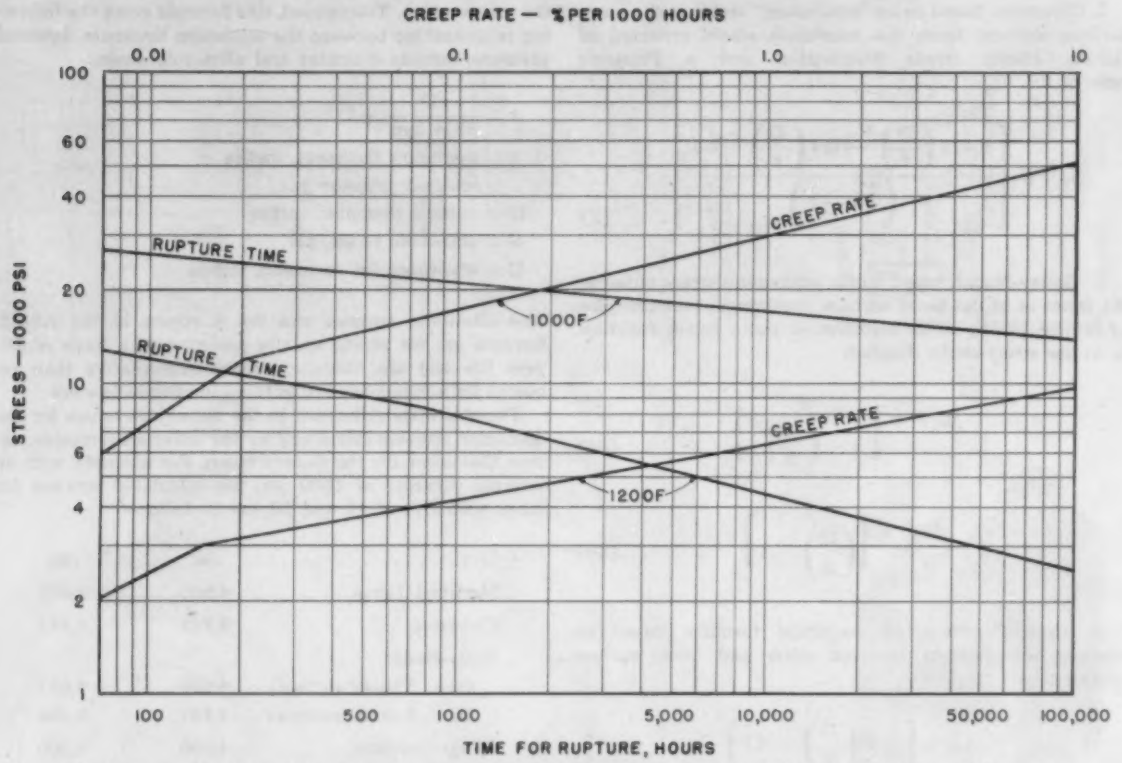

FIG. 5. Creep strength — stress to rupture relationship for 2¼ chrome-mo steel. —Courtesy Babcock and Wilcox Co.

hr or stress to rupture in the same period is super-conservative for the normal useful life of tubes in a process heater. Another factor that contributes to overdesign with these stresses is that the accepted values are obtained with continuous application of stress and temperature. When the tests are interrupted periodically by removing the stress and cooling the specimen the values obtained with interrupted tests are consistently higher than with continuous tests. Apparently, during the interruptions, a certain amount of relaxation occurs that makes the material relatively stronger. The same relaxation should occur during the normal shutdowns, thus providing the material with even greater potential strength than would be indicated by the already conservative values for 1 per cent creep or stress to rupture in 100,000 hr.

Some designers use a time-function factor for the stress for creep in 10,000 hr to determine the allowable stress during the useful life of the tubes.

One type of the time function formula is:

$$S_a = S_c(1 - 0.02n) \quad \ldots\ldots\ldots\ldots \quad (7)$$

for the original life of the tubes and,

$$S_a = S_c(1 - 0.04n) \quad \ldots\ldots\ldots\ldots \quad (8)$$

for the residual life of tubes approaching the retirement thickness where,

S_a = allowable stress, psi
S_c = stress for creep of 1 per cent in 10,000 hr, psi
n = tube life in years

The original life and residual life as obtained from the respective formula is then checked against the time to rupture with the actual stress in the tube. The following is an example for using formula (8).

Actual working stress 4000 psi. Material 2¼ chrome-Mo, Metal temperature 1200 F. Will the tubes be safe for another run of 12,000 hr?

From Fig. 5, S_c = 4300 and from formula, S_a = 4100. S_a is just barely above the actual working stress and, while satisfactory, may be "too close for comfort." By following the 4000 psi coordinate on the creep curve to the intersection with the stress to rupture curve, the rupture time, however, is approximately 16,000 hr, or approximately 5½ months longer than the expected run, indicating that a working stress of 4000 lb is safe for this length of run. Conversely, starting with a length of run of 12,000 hr, the stress to rupture is 4200 psi, which is higher than the S_a of 4100 psi from the formula and the actual working stress, indicating that the tube will not rupture during the run.

The long-time strength of alloys decreases with temperature and drops off rather rapidly as the maximum practical temperature is approached. Therefore, the actual maximum operating metal temperature must be determined as accurately as possible to obtain the true strength requirements of the alloy. In well designed heaters without scattered hot spots or continuous zones of local over-heating, the maximum operating metal temperature can be determined from the average metal temperature as calculated from the average heat input rates in the heater. The average metal temperatures of the tubes, T_m, can be expressed as:

$$T_m = T_o + \Delta tf + \Delta td = \Delta tm, \text{ where}$$

T_o is the bulk temperature of the fluid and the Δt's are the temperature drops through the film, the deposit and the clean metal. The individual t's, in turn, are obtained from the general relationship $\frac{Q}{Ah}$, where Q is the total heat supplied to the fluid, Btu/hr and A the respective heat trans-

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PETROLEUM CHEMICALS DIVISION
NEWS

April ★ One of a Series of Interest to the Petroleum Industry ★ 1956

Question Box

1. HOW MANY of your products can be protected against copper contamination?
   Count them in the article at right.
2. ARE YOU considering a new automatic component blending setup?
   If so, you will want to look into the service offered below.
3. WHO heads up the Du Pont Petroleum Laboratory?
   You'll "meet" him when you turn the page.
4. HOW CAN you be sure the heating oil you put into storage now will still be stable next winter?
   The information on the next page may help you make sure.

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OVER

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CONTINUED *Metal Deactivator*

mendations can help you achieve your desired stability with less additive . . . often at a substantially lower treating cost.

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DR. BERNARD M. STURGIS is director of the Du Pont Petroleum Laboratory, heading up all technical and customer service activities of the Petroleum Chemicals Division.

A native of Indiana he graduated with an A.B. degree from De Pauw University. Three years later he received his Ph.D. degree in organic chemistry from the Massachusetts Institute of Technology.

Then, in 1936, he joined the Du Pont Company as a research chemist at the Jackson Laboratory. In 1951 he was transferred to the Petroleum Laboratory as head of the combustion and scavenging division. He later became assistant director and finally director of the laboratory.

For his paper, "Some Concepts of Knock and Antiknock Action," he recently received the Horning Memorial Award in January 1956. This is the third time the Horning Award has been presented to a scientist from the Du Pont Petroleum Laboratory. It was previously awarded successively to Daniel L. Pastell and Leon F. Dumont for their work on precombustion reactions and combustion chamber deposits.

Dr. Sturgis is active in many technical societies and organizations, including the Combustion Institute, the American Chemical Society, the Society of Automotive Engineers, the American Petroleum Institute, and the Coordinating Research Council.

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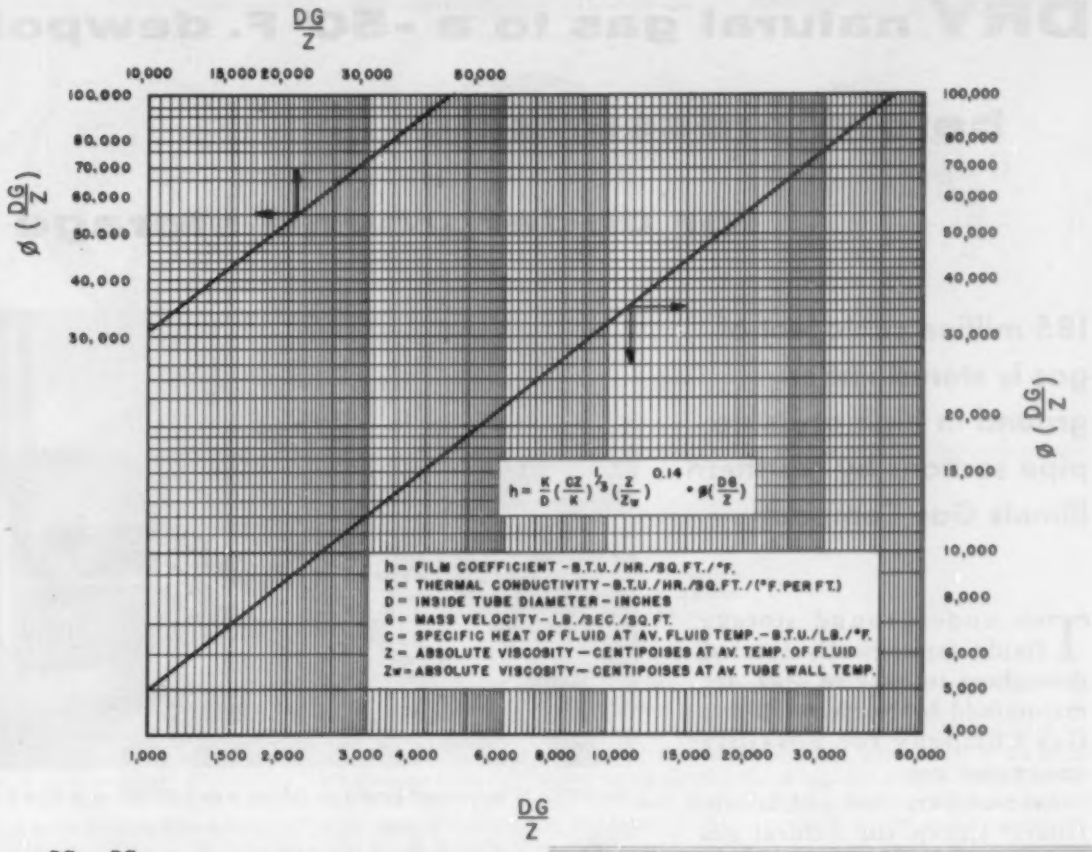

FIG. 6. $\phi \frac{DG}{Z}$ vs $\frac{DG}{Z}$ for film drop coefficients. (Based on Maxwell.)

fer surfaces based on the OD of the tubes for the metal, the ID of the tubes for the deposit and the ID of the deposit for the film, and h the conductivities of the metal, the deposit and the film.

The temperature drop through the film is usually the highest. Most commonly used formula for h_f, in process heaters is

$$h = \frac{K}{D}\left(\frac{CZ}{K}\right)^{\frac{1}{3}}\left(\frac{Z}{Z_w}\right)^{0.14}\phi\left(\frac{DG}{Z}\right).$$

If, the temperatures of the fluid in the heater, Z and Z_w, are small and almost equal, the viscosity factor can be neglected. General procedure for calculating the average operating metal temperature is shown on Table 4.

In modern heaters, the major portion of the total heat is supplied in the radiant section to tubes arranged in single or double-row banks along the walls, or the walls and the roof of the heater. Individual rates of radiant heat input, or "flux distribution," around the circumference of tubes are not uniform so that the average flux and the average rates are intermediate between the maximum and the minimum.

Fig. 7 shows the relative radiant heat flux intensity along the circumference of tubes in single and double-row banks for a tube spacing of two diameters. With a maximum flux of unity at Point 1 of the circumference, the average flux along the circumference of tubes in single-row banks is 0.562. With double-row banks and the same maximum flux of unity, the average flux for the tubes in the first row is 0.437 and for the second row 0.186. The overall average flux intensity for both rows is 0.311. With these relationships and with an average heat input rate of 10,000

TABLE 4. Example. Calculations of tube metal temperature.

Conditions
Charge — 32 F API flashed crude, 92,000 lb/hr
Ave. temp. — 700 F
Tube — 4 in. ID; 4.5 in. OD; 0.25 in. Wall
Heat input rate — 10,000 Btu/hr/sq ft of OD surface of tube
Deposit — 1/16 in. thick

Formula $h = \frac{K}{D}\left(\frac{CZ}{K}\right)^{\frac{1}{3}}\left(\frac{Z}{Z_w}\right)^{0.14}\phi\frac{DG}{Z}$

From Maxwell

$K = .0633$; $C = 0.785$; $Z = 0.18$; $Z_w = 0.15$, appr. neglect $\frac{Z}{Z_w}$

$G = 294$ lb/sec/sq ft, with clean tubes
$= 314$ lb/sec/sq ft, with deposit

$\frac{K}{D} = 0.0158$ with clean tubes
$= 0.0163$ with deposit

$\left(\frac{CZ}{K}\right)^{\frac{1}{3}} = \left(\frac{0.785 \times 0.18}{0.0633}\right)^{\frac{1}{3}} = (2.23)^{\frac{1}{3}} = 1.31$

$\frac{DG}{Z} = \frac{4 \times 294}{0.18} = 6550$ with clean tubes
$= \frac{3.875 \times 314}{0.18} = 6750$ with clean tubes

$\phi\frac{DG}{Z} = 22{,}000$ with clean tubes
$= 23{,}000$ with deposit

$h = 22{,}000 \times .0158 \times 1.31 = 455$ with clean tubes
$= 23{,}000 \times .0163 \times 1.31 = 495$ with deposit

Heat Transfer Rates
Through tubes, 4.5 in. OD = 10,000 Btu/hr/sq ft
Through film, clean, 4 in. OD = 11,200 Btu/hr sq ft
Through film with deposit, 3.85 OD = 11,700 Btu/hr/sq ft
Conductivity of metals Btu/hr/sq ft/inch/F
Carbon Molly 310; 5 chrome 190; 18-8 = 113
Conductivity of deposit = 41, Btu/hr/sq ft/inch/F
Δt, film = 11,200 : 455 = 24.6 clean tubes
= 11,700 : 495 = 23.9 with deposit
Δt, deposit = 11,200 : (41 × 16) = 17.1
Temperature drops, based on average rates

	Carbon - Mo	5 Chr	18-8
Δt, metal	8	13.2	22.2
Total Δt, clean tubes	32.6	37.8	46.8
Total Δt, with deposit	49.0	54.2	63.2
Total Δt at points of maximum flux, with deposit.			
Normal, at 1.78 ave. F	87	96	112
At hot spot, at 3.0 ave. F	147	163	190
"Average" metal temperature, F with charge at 700 F and deposit	749	754	763
Normal maximum, F	787	796	812
Maximum at hot spot, F	847	863	890

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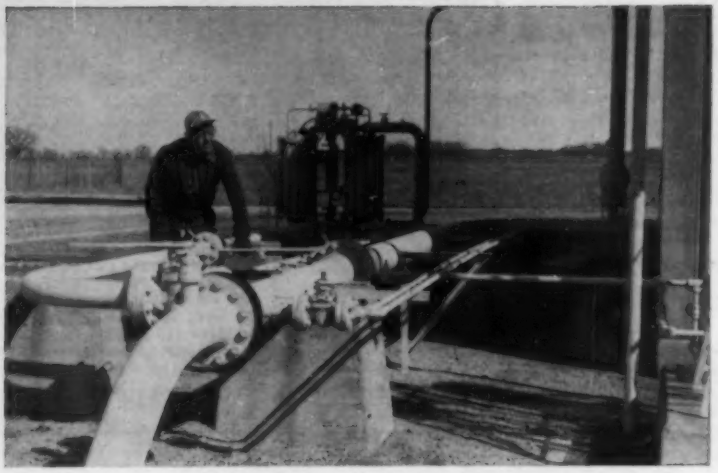
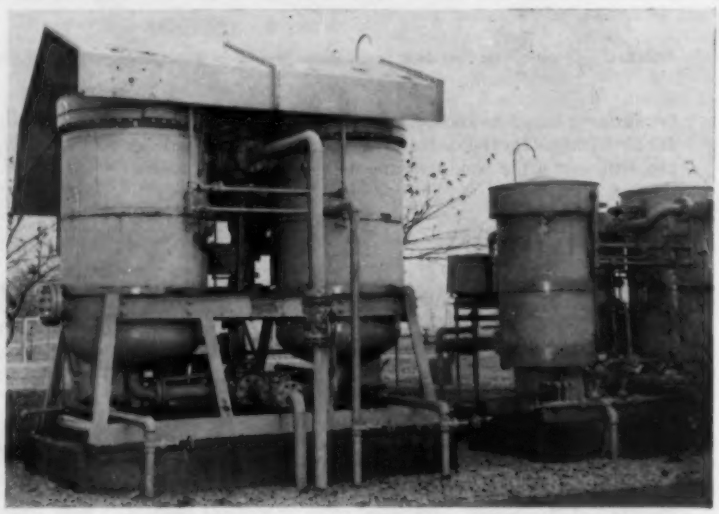


This BWC-150 Lectrodryer handles the DRYing at the 4,800,000 cu. ft. Rock Falls plant.*



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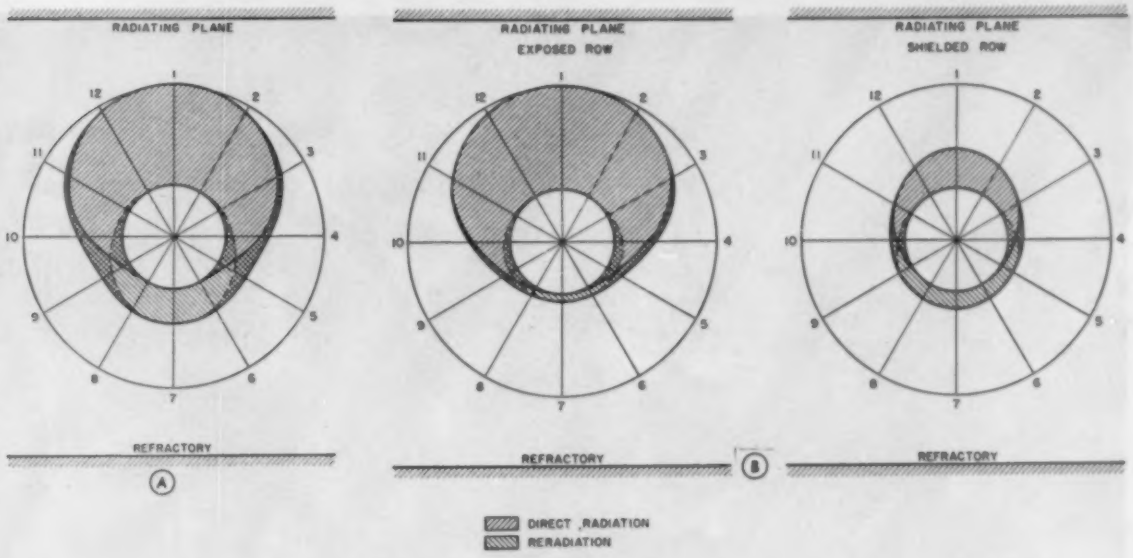

FIG. 7. Radiant heat flux distribution along circumference of tubes: (A) Single-row banks; (B) double-row banks. Heaters G and L, each row same as (A).

Btu/hr/sq ft of total circumferential surface of the tubes, and assuming no heat flow from the points of higher flux to the adjoining point on the circumference, the maximum flux or heat input rate at Point 1 for tubes in single-row banks is approximately 17,800 Btu. With average rates of 10,000 Btu for both rows in a double-row bank, the maximum flux is 32,000. Conversely, if the maximum flux is limited to, say, 20,000 Btu, the average circumferential rates in single-row banks will be approximately 11,100 Btu/hr/sq ft and in double-row banks approximately 8600 Btu for the first row, 3600 Btu for the second row and 6100 Btu for the average of both rows.

In some heaters, a portion of the radiant tube bank is so located that the main stream of the gases has to pass over this portion before the gases leave the radiant section of the heater. This portion of the coil usually referred to as the "shock tubes" or "shock bank" is identified as SB in Fig. 1. The shock tubes have a convection heat component superimposed on the radiant heat rates so that the combined rates in these tubes are considerably higher than the average for the total radiant coil, particularly if the gases pass over the shock tubes at high velocities, as would be the case in heaters B, D, F and L where the tubes are spaced on the same or closer center than the radiant tubes. In heaters E and C, the shock tubes are spread out to keep the convection component to a minimum. The convection component applied to the shock tubes is also not uniformly distributed along the circumference of the tube, so that the maximum flux at Point 1 of the first row of the shock tubes must be increased by more than the average rates of the superimposed convection rates. Depending on the rate of firing, the maximum flux in the first row of shock tubes may be 2.5 to 3.0 times the average rates calculated on the basis of the total heat input and the total surface of the radiant and shock tubes in the heaters, even when allowing for heat flow through the metal circumferentially to somewhat equalize the flux distribution.

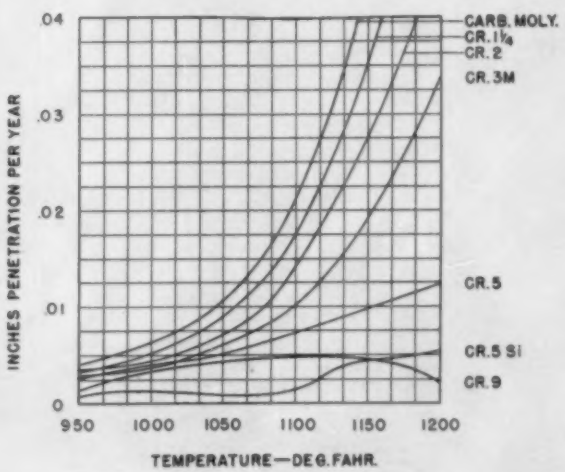

FIG. 8. Oxidation rates of ferritic alloys. — Courtesy Babcock and Wilcox.

With a corrosive charge, proper evaluation of the maximum metal temperature is even more important than in heaters operating with non-corrosive charge because the rates of corrosion increase quite rapidly with increase in metal temperature as shown in Table 2. Quite often, excessive corrosion of tubes in a particular section of a coil is due not to the charge being extra corrosive through the temperature range in the section, but to much higher metal temperatures than the temperatures calculated on the basis of uniform, average heat input rates to the radiant and the shock tubes of the heater.

In addition to corrosion, the metals of the tubes are subject to oxidation. Fig. 8 shows the oxidation rates of different ferritic alloys through the temperature range between 950 F and 1200 F. Generally, the relative oxidation resistance of the alloys is of importance only when processing non-corrosive stocks because with corrosive stocks requiring 5 and higher chrome alloys, the alloys will withstand the relatively mild oxidation conditions of the products of combustion obtained with excess air of 20-30 per cent normally used in well designed heaters.

End Part 2

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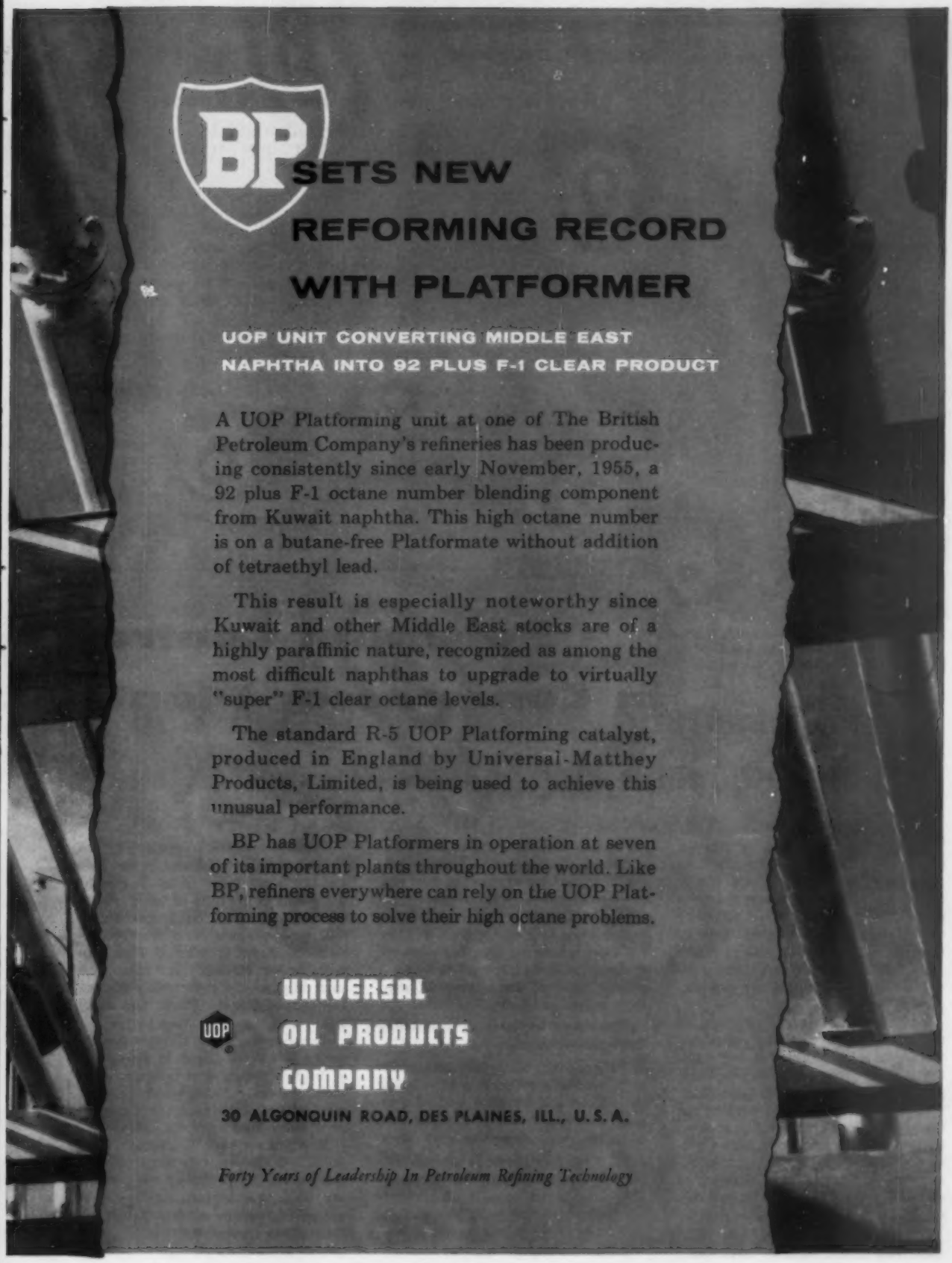
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—Editor.

EXCLUSIVE

Pulsation Control in Compressor Plants

C. Newman and N. H. Moerke

The Fluor Products Company

GAS pulsations created by reciprocating compressors are often a serious problem in compressor plants. Under conditions of normal compressor operation, the amplitude (peak to peak) of such pulsations are in the range of 6 to 10 per cent of operating pressure. Abnormal compressor operation produces amplitudes which may even exceed 10 per cent.

The major problem is vibration of the piping, induced by the pulsations, within the plant area or at some distance from the compressors. These pulsations result in serious pipe vibration when the natural frequency of the pipe span or configuration is equal to the pulsation frequency. Pipe vibration results in the generation of extraneous noise and dynamic stressing of the pipe with subsequent fatigue failure of the piping.

*Condensed by the authors from ASME paper "Control of Pulsations in Piping Systems," New Orleans, September 25-29, 1955.

Another serious problem is the adverse effect gas pulsations have on orifice-plate flow measurements. The pulsations cause flow recorder pens to oscillate to the extent that it is difficult to determine an accurate average. Even for cases where the recorder pens are damped to the extent of drawing a smooth line, an error can still exist from pulsation effects.

Two basic methods of controlling these pulsations are:

1. Resistive: Methods wherein efficiency is a function of pressure drop and which consist of a reduction in area of the flow path such as orifice plates and valves.
2. Reactive: Methods wherein efficiency is a function of frequency and which consist of properly designed changes in pipe sections and internals such as low or high pass dampeners.

Resistive methods of controlling gas pulsations have been used in the past and are occasionally found in present day plants in the form of orifice plates and pinched valves. The general use of this type of control is not recommended. Resistive method disadvantages of low efficiency and high pressure drop normally override their advantages of low initial cost and small size.

The simplest form for this control device is a valve placed in the system at the point which requires control. The more elaborate form, which requires a knowledge of design, is the placing of an orifice within a volume chamber.

Reactive methods of controlling gas pulsations are presently in use on systems where reciprocating compressors are used to compress and transport gas. This reactive method is used in three basic type dampeners: (1) side-branch resonators, (2) high-pass damp-

Extruded Incoloy tubes help keep gas reforming costs down. They are economical in cost and possess the necessary characteristics of strength, and heat- and corrosion-resistance. Shell reacts natural gas and steam in them at money-saving high pressures and temperatures.

How Incoloy reduces gas reforming costs in Shell's new anhydrous ammonia plant

High pressure, 1700°F reaction in extruded Incoloy tubes permits major operating economies

Today, anhydrous ammonia is cheap and plentiful . . .

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Shell Chemical Corporation makes this low-cost NH_3 in Pittsburgh, California and in its new plant at Ventura. They synthesize it from nitrogen plucked out of the air, hydrogen squeezed out of natural gas.

At the new plant, in the gas reforming stage, Incoloy* iron-nickel-chromium alloy helps Shell make several big economies.

Keeping the pressure high during the reforming operation results in a 25-30% saving in compressor horsepower when the synthesis gas is fed to the converters.

So Shell takes the natural gas at its high line pressure, heats it to 1700°F and reacts it with steam in extruded Incoloy tubes packed with catalyst.

This iron-nickel-chromium alloy provides the high creep and rupture strengths needed for this high temperature, high pressure reaction. It does not tend to suffer embrittlement as a result of phase changes. It resists oxidation and corrosive effects of the methane-steam mixture. What's more, the extruded tubes proved more economical than other materials considered for the application.

If your new developments include gas reforming at high pressures and temperatures, you may want to look into Incoloy. Just write Inco's High Temperature Engineering Section.

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eners, and (3) low-pass dampeners.

Side-branch resonators are absorption devices that give negligible pressure drop to the system. They have a limited frequency range and can be used to advantage on essentially constant speed compressors.

Forms of this type device are composed of volume chambers and orifice plates, volume chambers and pipe lengths or just pipe lengths. All forms can be attached to the laterals, headers or the normal surge chambers of the compressors as a side branch.

High-pass type dampeners allow passage of the high frequencies and attenuate the low frequencies. They can be designed to have low pressure drop with high attenuation characteristics for pulsation control. They have a recurrent attenuation characteristic which allows alternate bands of passed and attenuated frequencies.

Forms of this type of control device are composed of a length of perforated pipe and external shell which can be inserted in the lateral (in-line dampener), or replace the normal volume (manifold dampener) bottle of the compressor.

Low-pass type dampeners allow passage of the low frequencies and attenuate the high frequencies. These can also be designed for low pressure drop with high attenuation characteristics for pulsation control. They have a recurrent attenuation characteristic which allows alternate bands of passed and attenuated frequencies.

Forms of this type dampening device are composed of two chambers and an interconnecting pipe. They can be adapted to almost any configuration.

The manifold configuration is so designed that one chamber of the dampener is used as the volume bottle for the compressor cylinder, thereby replacing the normal volume bottle.

The in-line configuration consists of an elongated shell which is divided into multiple chambers with appropriate interconnecting tubes and is inserted in the lateral piping as close to the compressor as possible.

The two-bottle dampener configuration consists of two separate chambers connected by a properly sized tube, with one chamber serving as the manifold volume bottle and the second being inserted in the lateral.

General characteristics of the various methods of controlling pulsations is tabulated in Table 1. Each method has a definite use dependent upon the existing circumstances surrounding the pulsation problem. The high-pass and low-pass dampeners have the wider utility with the low-pass dampener being the more adaptable to various design situations.

TABLE 1. Advantages and disadvantages of the different types of dampeners.

Type dampener	Advantages	Disadvantages
Resistive	Essentially insensitive to frequency.	Low efficiency. High pressure drop.
Resonator	Negligible pressure drop. High efficiency.	Limited frequency range. Limited configurations. Requires constant speed operation.
High Pass	Low pressure drop. High efficiency. Wide frequency range.	Passes high frequencies. Recurrent dampener. Limited configurations.
Low Pass	Low pressure drop. Wide frequency range. High efficiency. Adaptable to many configurations.	Passes low frequencies. Recurrent dampener.

How much pulsation control or dampening is required to prevent vibration or metering errors? This question is difficult to answer specifically since each type of plant is slightly different in design and operation. However, some general ranges of acceptable residual pulse pressures can be ascertained.

Where vibration is a problem, these ranges fall into two categories dependent upon the basic plant design.

1. In plants that follow the pattern of grade type piping and that are well designed in accordance with dynamic relations for structural supports, 1¼ per cent (½ peak to peak) of average pressure is acceptable.
2. In plants that follow the pattern of overhead piping, there is more room for errors in the dynamic relations of structural supports. As a result there are two regions of acceptability: 1¼ to ¾ per cent (½ peak to peak) of average pressure for the well designed plants, and ¾ to ½ per cent (½ peak to peak) average pressure for plants of average design.

Where metering accuracy is a problem, the maximum residual pulse pressure ranges from ¼ to 1/10 per cent (½ peak to peak) of average pressure and is dependent upon type and range of the meter and its position in relation to compressors.

P 757.

EXCLUSIVE

Fluid Coker

Mechanical Design Aspects

R. H. Maass and E. J. Newchurch

Esso Engineering Design Division

FLUID coking is a simple rugged continuous process employing no catalyst. It depends on the heat and surface area provided by a circulating stream of finely divided coke particles. A diagrammatic flow plan of the fluid coking plant is shown in Fig. 1.

The apparatus is quite similar to a fluid catalytic cracking unit. It consists of a reactor or coking vessel in which the feed is converted into dry gas, naphtha, gas oil and small coke particles, and a burner vessel where a part of the circulating coke is burned to supply heat for reaction. The reactor and burner vessels contain fluidized beds of finely divided particles of coke at temperatures of about 950 F and 1125 F, respectively. The vessel top pressures are in the order of 5-10 psig. Circulation lines are provided to transfer coke between the vessels continuously.

Feed coming from the bottom of a vacuum tower at temperatures in the order of 500-700 F is injected directly into the reactor through multiple steam-atomizing nozzles. Upon entering the reactor, the feed partly vaporizes and partly cracks as it is heated up rapidly by the hot fluidized coke. Steam injected at the bottom of the reactor along with vaporized feed fluidizes the coke bed. Excellent mixing takes place, hence there is very little temperature spread in the reactor just as in the case of fluid catalytic cracking. The vapor

*Condensed by the authors from the ASME paper, "Fluid Coker Design — Mechanical Aspects," New Orleans, September 25-28, 1955.

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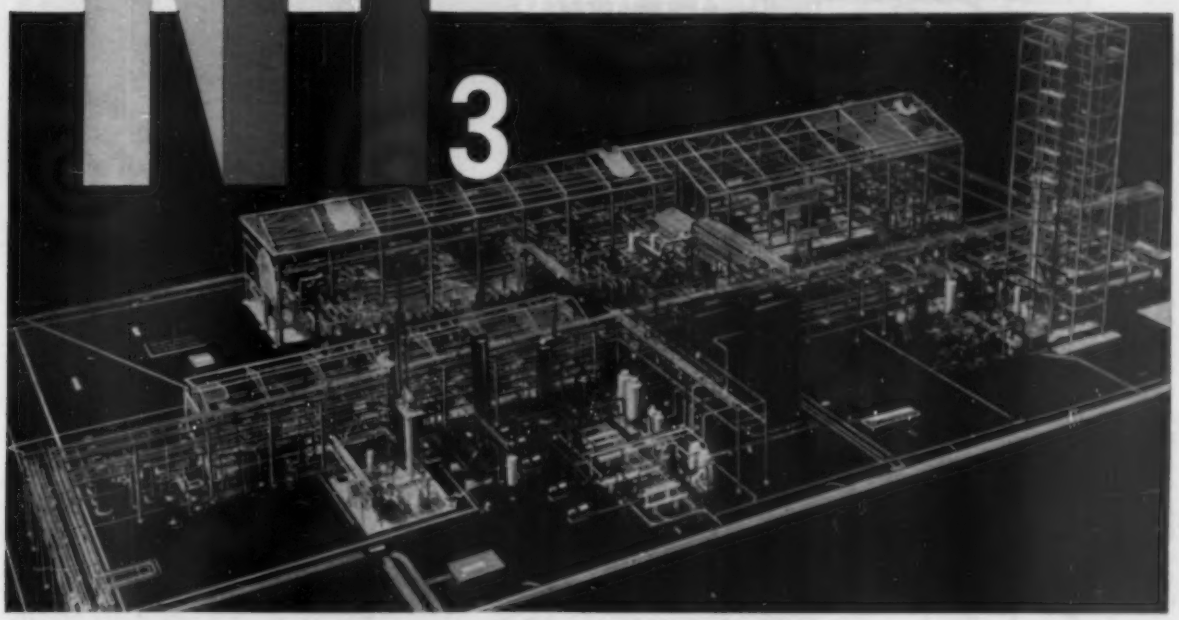

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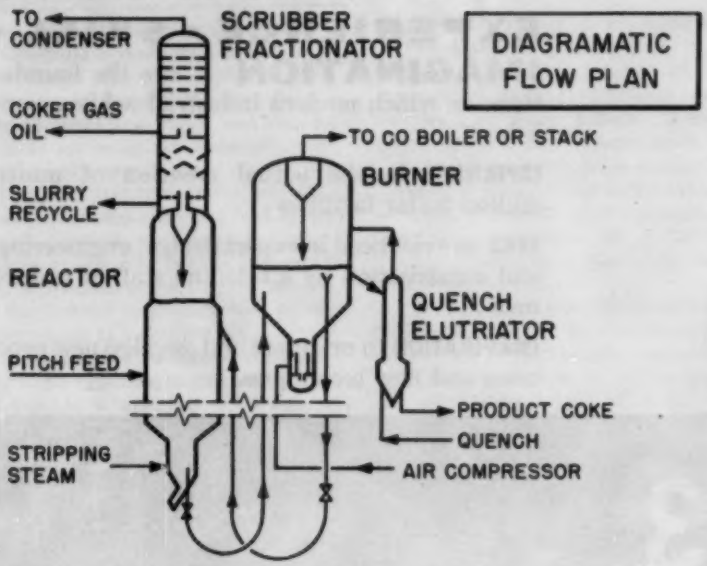

FIG. 1. Diagrammatic flow plan of fluid coker unit.

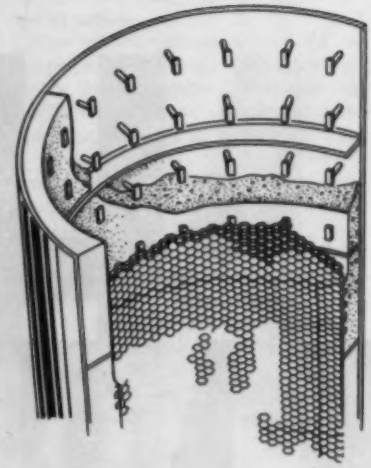

FIG. 2. Refractory, and insulating concrete, lining.

products from the fluid bed are taken overhead through a cyclone separator.

Most of the entrained coke particles are separated at this point and are returned to the fluid bed. The small amount of coke fines that passes through the cyclones is returned to the coker along with the unconverted portion of the feed, which is condensed in a scrubber vessel ahead of the fractionator. Vaporized products from the coking process pass through the fractionator and the gas, gasoline and gas oil fractions are then directed toward normal refinery handling processes.

To maintain reactor temperature, coke flows continuously to the burner through one transfer line and back to the reactor in another line. Each of these transfer lines consists of a standpipe and riser. A pressure balance is maintained to promote and control circulation by variation of pressures, levels and densities. Coke flow between the reactor and the burner, and reactor level are controlled by slide valves. The burner coke level is regulated by controlling flow of coke to a quench-elutriator vessel. Combustion air is supplied to the burner by a centrifugal blower. The air passes through the coke bed burning approximately 20 per cent of the total coke produced from a typical coker feed. The oxygen in the air is almost completely consumed.

Coke is withdrawn from the burner vessel to the quench elutriator where water is injected to cool the product coke. Steam generated in the quenching operation strips of coke fines out of the elutriator feed stream and returns them to the system. Elutriator bottoms constitute the product coke.

Reactor-Scrubber-Fractionator

The reactor-scrubber-fractionater is designed in accordance with the unfired pressure vessel codes. The scrubber-fractionator is "stacked" above the reactor to minimize the time before the heavy reactor products are quenched to below their dew point at about 600-700 F. This combined vessel is built of carbon steel even though the operating temperature of the reactor may be as high as 1000 F.

The section of the reactor where fluidized coke and reactor vapors are present is lined with a refractory and insulating concrete material. Construction of this lining is depicted by Fig. 2.

The 8-in. lining, which is 4 in. thicker than that normally used in catalytic-cracking plants for this temperature, is provided to compensate for an increase in thermal conductivity of the insulating concrete from vapors permeating the lining and coking upon condensation. The refractory-layer reinforcing mesh is of 12 per cent chrome-alloy steel for corrosion resistance. Installation of the heat-insulating lining in the reactor reduces the actual shell metal temperature to approximately 300 F. No external insulation is provided in this section.

The scrubber-fractionator shell is fabricated of carbon steel with 12 per cent chrome cladding for corrosion resistance. The scrubber is externally insulated. Temperature gradients between the scrubber shell and the top of the reactor are minimized by extend-

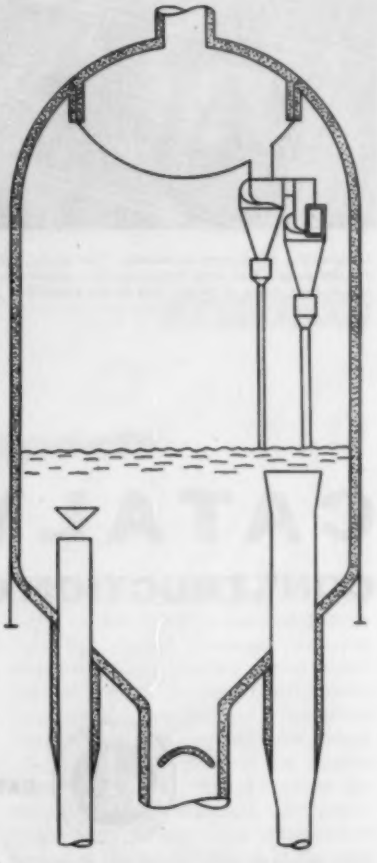

FIG. 3. Elevation of the burner vessel.

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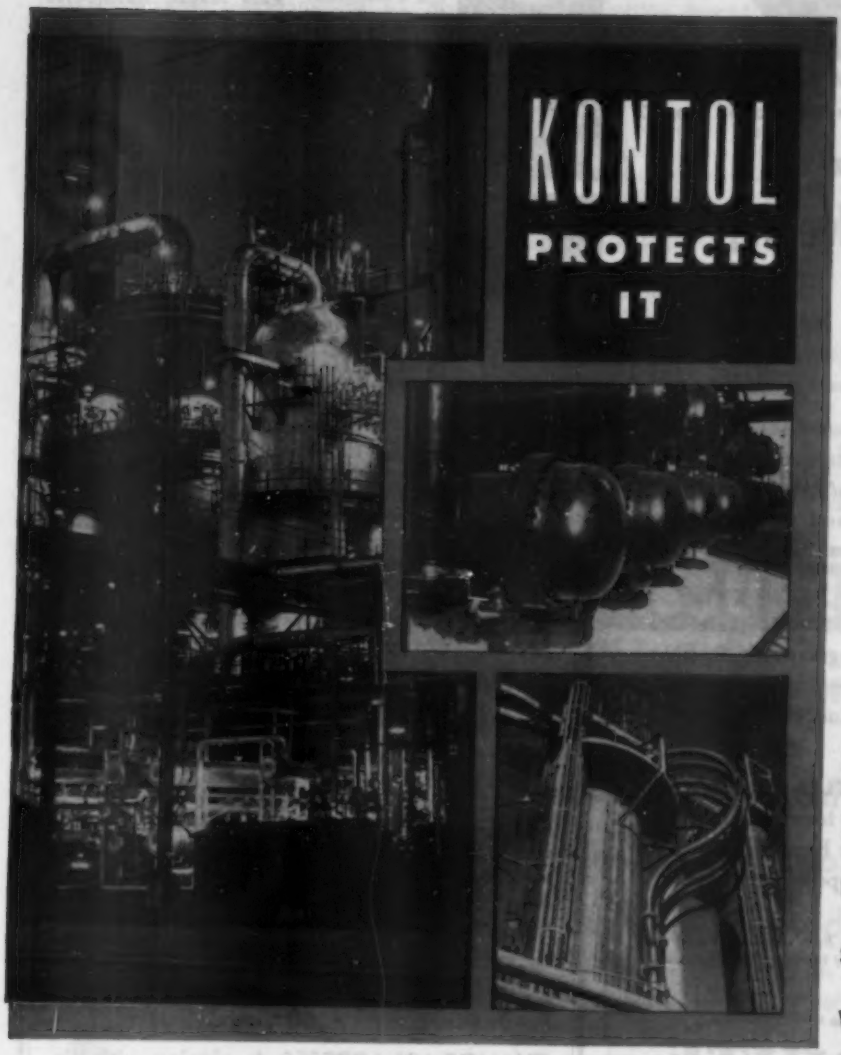

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ing the external insulation over the lined transition and by terminating the insulation with a gradual taper.

Burner

The burner vessel houses the operation where heat is supplied to the circulating coke particles by burning part of the coke. This vessel, as shown in Fig. 3 is quite similar to regenerators in fluid catalytic-cracking units. The carbon-steel shell is protected from the 1100 F operating temperature by a 4-in. reinforced refractory and insulating concrete lining. The reinforcing mesh in the dense bed zone is of 12 per cent chrome-alloy steel for oxidation resistance. The coke bed is fluidized by the injection of air through a distributor. The excellent mixing accomplished by fluidizing the coke particles results in a uniform coke temperature.

Flue gases ladened with coke particles pass through two stages of large-diameter cyclone units. These cyclones remove practically all of the entrained coke from the gas and return it to the bed.

Quench Elutriator

Purpose of the quench elutriator is to cool product coke and at the same time return the small-diameter coke particles to the burner. The vessel is fabricated of carbon steel with a conventional 4-in.-thick reinforced refractory and insulating concrete lining. Internal parts are made of carbon-steel material and are supported from the shell through sliding connections that accommodate differential thermal expansion.

Transfer Lines

As shown in Fig. 1 both the cold and hot coke circuit consist of a standpipe section, a slide valve, and riser. The materials of construction depend on the diameter of the lines. For diameters less than 24 in. the cold-coke circuit is of carbon-steel material and the hot-coke circuit of 5 per cent chrome-alloy steel for strength purposes. When large diameters are specified the cold-coke circuit is made of carbon-steel pipe externally insulated and lined with a 12 per cent chrome-reinforced refractory lining for erosion protection. The hot-coke circuit is constructed of carbon-steel pipe internally insulated with a 3½-in.-thick 12 per cent chrome-reinforced refractory and insulating lining. In this case the pipe would have no external insulation.

Aeration connections are provided to maintain the coke particles in a fluidized condition. The aeration piping is so arranged that if a nozzle becomes plugged with coke it can be reamed out while the unit is operating.

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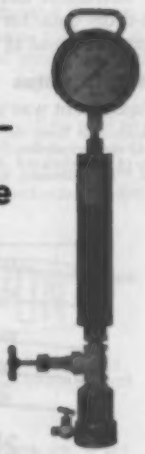

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P 621.

EXCLUSIVE

Pressure Drop of GAS-LIQUID MIXTURES in Horizontal Pipes

J. M. Chenoweth and M. W. Martin
The C. F. Braun Company

IN many industrial plants, gases and liquids flow together in pipes as a two-phase mixture. For example, two-phase mixtures pass through fired-heater tubes and transfer lines in refineries, through pipe line contactors in chemical plants, and through hot condensate lines in utility systems. For all of these cases and many more, the engineer needs to be able to predict pressure drop. The most generally accepted correlation for predicting two-phase flow pressure drop is the method of Lockhart and Martinelli.[1] This method was developed from data for small-diameter pipes and for pressures from atmospheric to 50 psi. But many applications of two-phase flow fall beyond these limits. This investigation was undertaken to check the Lockhart and Martinelli correlation with pressure-drop data for two-phase flow in larger pipes and at higher pressures.

Test Apparatus

Equipment was set up to get isothermal-flow data for air-water mixtures. The test-apparatus included the test section itself, a system for mixing and circulating the fluids, and means for measuring pressures, temperatures and flow rates. Two interchangeable 35-ft test sections were used. One was made from 1½-in. and the other from 3-in. galvanized steel pipe.

Two-Phase Tests

During the experimental program, 264 isothermal two-phase pressure-drop tests were made. The gas and liquid flow rates were systematically selected at equal logarithmic intervals before the tests began. In this way, the results could be conveniently cross-plotted to check internal consistency. In addition, the entire range of accessible test-conditions was uniformly covered. Uniform coverage is of particular value in assessing the accuracy of flow correlations. The lower limit of flow rates was set by either the sensitivity of the pressure-drop measurements or the start of turbulent flow, while the upper limit was set by the capacity of the apparatus.

Lockhart-Martinelli Check

The test results were used to check the Lockhart-Martinelli correlation, and the deviations follow a clearly defined pattern. The data for the 1½-in. pipe near atmospheric pressure generally follow the correlation. All of the test points are within plus 28 per cent and minus 49 per cent, which is within the accuracy claimed for the correlation. The data for the 3-in. pipe at 100 psi deviate the most from the correlation with all points falling low. The correlation predicts pressure-drops up to 2.5 times as great as those actually measured. In general, deviations increase as either pipe size or gas density is increased beyond the range of data available when the Lockhart-Martinelli correlation was published.

Improved Correlation

An improved correlation for two-phase structure pressure drop in horizontal pipes was developed from the test data for the 1½-in. and 3-in. pipes. The correlation is empirical, just as all earlier ones have been. It can be used for any liquid-vapor mixture as long

*Condensed from the ASME paper, "A Pressure-Drop Correlation for Turbulent Two-Phase Flow of Gas-Liquid Mixtures in Horizontal Pipes," New Orleans, Louisiana, September 25-28, 1955.

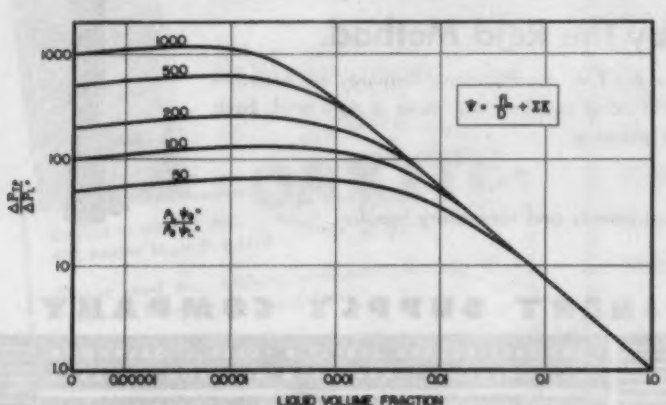


FIG. 1. Correlation for turbulent two-phase pressure drop in horizontal pipes.

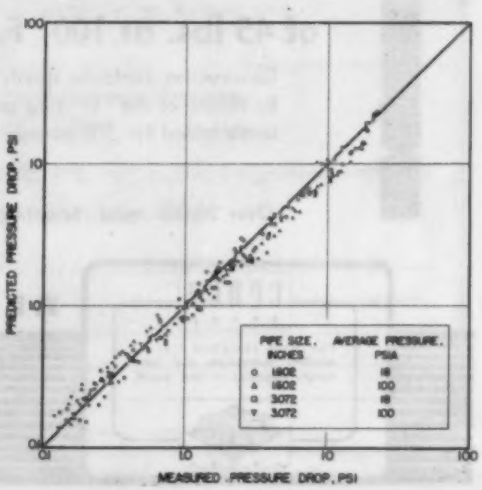
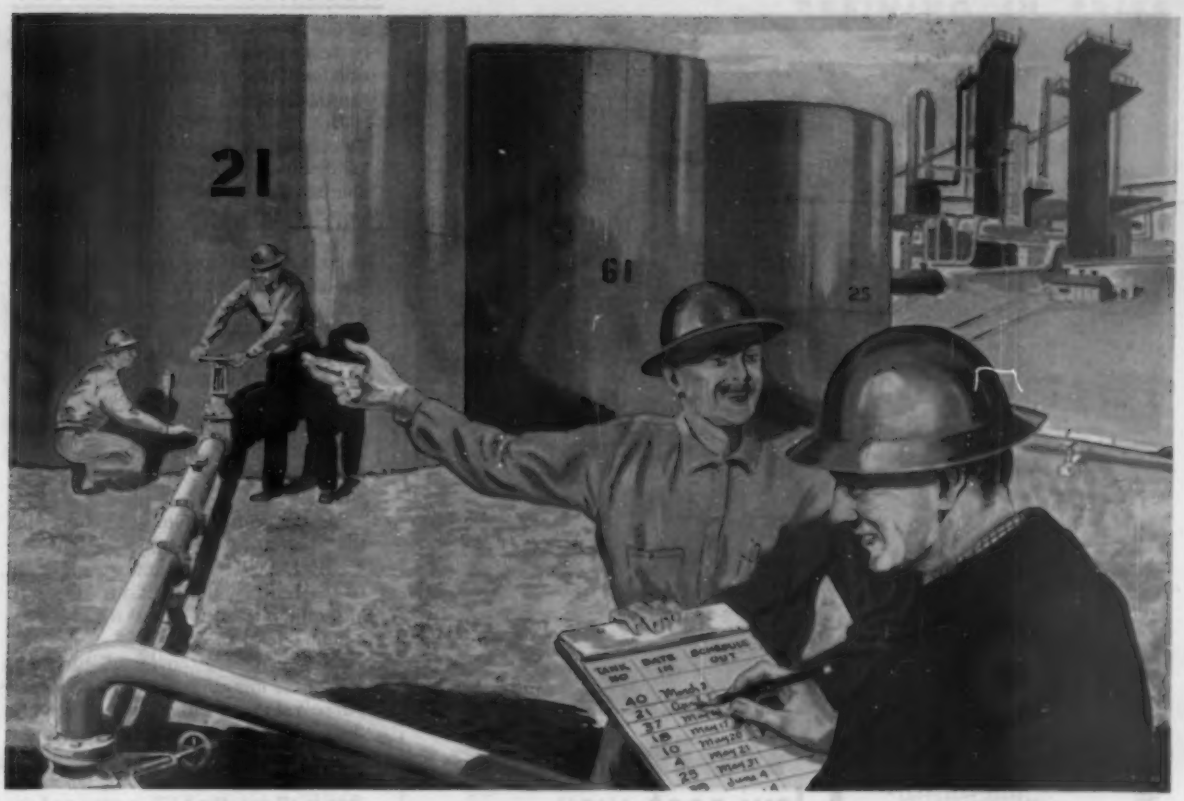


FIG. 2. Test of this correlation with data for horizontal pipes.



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as the flow is turbulent. The improved correlation uses a liquid volume fraction and two pressure-drop ratios as the parameters.

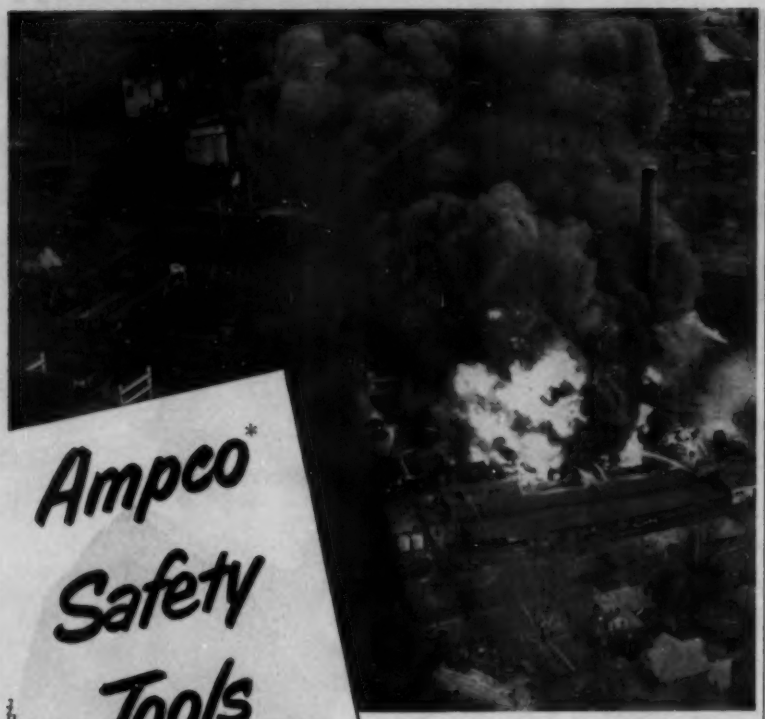
Fig. 1 shows the abscissa as the superficial liquid volume fraction, or LVF, of the mixture. This quantity is computed from the flow rates and densities of the phases. The ordinate is $\Delta P_{TP}/\Delta P_{L_e}$, the ratio of the two-phase pressure drop to a fictitious all-liquid pressure drop. The all-liquid pressure drop is computed from the total mass flow (W_L+W_G) and the physical properties of the liquid phase. The concept of the all-liquid pressure drop is useful, as it allows the correlation to be tied into single-phase results and eliminates ambiguity about the physical properties to use in the calculations.

On the grid is a family of curves for the parameter $P_L\psi_G/\rho_G\psi_{L_e}$, where $\psi=fL/D+\Sigma K$. The parameter is equal to the ratio of the fictitious all-gas to all-liquid pressure drops for the pipe system.

The correlation covers all turbulent two-phase mixtures and ties into single-phase values at either end. When the flow is all liquid, the LVF equals 1.0 and the ratio $\Delta P_{TP}/\Delta P_{L_e}$ is also equal to 1.0. On the other hand, when the flow is all gas, the LVF is zero and the ratio $\Delta P_{TP}/\Delta P_L$ is equal to $\Delta P_G//\Delta P_{L_e}$, so the pressure drop becomes ΔP_G.

Two-phase pressure drops predicted by this correlation are plotted against measured pressure drops in Fig. 2. Over 92 per cent of the calculated ΔP's are within 35 per cent of the measured values and all are within 50 per cent. The correlation also fits the test results of other investigators. All together, 506 different sets of data were checked, including tests run in pipes from ½ in. to 3 in. in diameter, pressures from atmospheric to 100 psi, and fluid systems including air with water, kerosine, benzene, and diesel oil. Average of the absolute deviations is about 20 per cent.

The correlation can be used to design most horizontal two-phase lines found in industrial plants. The only limitation is that the all-liquid Reynolds number must be greater than 2000. For flows with lower Reynolds numbers, the correlation will usually predict pressure drops that are higher than actually exist.



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Two-Phase Flow in Fittings

Very little information has been published on pressure losses for two-phase flow through fittings. Since this information is often as important as data on straight pipe, several representative 3-in. fittings were tested. These included a globe valve, a sharp-edge orifice, and a return bend. Pressure drops were measured across enough straight pipe on either side of the fitting to include most of the turbulence introduced by the fitting. Both single-phase and two-phase tests were made with each fitting. The two-phase tests covered a wide range of flow rates for pressures from atmospheric to 100 psi.

When the test results are compared with predicted pressure drops using the authors' correlations, nearly all agree within plus or minus 50 per cent of measured values. Thus the correlation can be used to predict pressure drop for systems containing fittings by using single-phase friction coefficients.

Copies of the original paper may be obtained on request from the authors.

Nomenclature

D Pipe diameter, ft
f Friction factor for Fanning Equation, dimensionless
K Friction coefficient for a valve or fitting, dimensionless
L Length of pipe, ft
W Flow rate, lb (mass)/sec
ΔP Pressure drop, lb (force)/sq ft
ρ Density, lb (mass)/cu ft
ψ Dimensionless group equal to

$$\frac{fL}{D} + \Sigma K$$

Subscripts

G Actual gas flow
G* Fictitious all-gas flow
L Actual liquid flow
L* Fictitious all-liquid flow
TP Two-phase

Reference

1. Lockhart, R. W. and Martinelli, R. C., Proposed Correlation of Data for Isothermal Two-Phase, Two-Component Flow in Pipes, *Chemical Engineering Progress*, Vol. 45, 1949, p. 39-48.

P 094.4

EXCLUSIVE

Sludge Formation and Additives Action

D. T. Rogers, W. W. Rice and F. L. Jonach
Esso Research and Engineering Company

STUDIES reported in this paper have shown that the bulk of low temperature, gasoline engine sludge is formed from the fuel rather than from the lubricant, when high-quality mineral oils are employed. In previous work on low-temperature sludge, the oil-insoluble solids in the sludge were usually considered as being formed in the combustion chamber. In contrast to this, the Esso Research work has shown that the major portion of the sludge appears to be formed in the crankcase lubricant from oil-soluble, low-molecular weight fuel oxidation products. These oil-soluble, sludge-forming intermediates have been isolated from used crankcase oils by chromatographic adsorption.

Sludge precursors are intensely red-colored liquids which are completely soluble in the lubricating oil. On heating at moderate temperatures, the "red oil" is rapidly converted into a brown resinous solid which is insoluble in oil. The "red oil" or the resins obtained from it when heated at high temperatures are converted into a hard lacquer which is insoluble in organic solvents. Conversion of "red oil" into sludge is accelerated by mineral acids. A simplified diagram of the mechanism is shown in Fig. 1. Chemically, the precursors contain polynuclear aromatics, alkyl aromatics, carbonyl linkages (aldehydes, ketones, and carboxylic acids) and a fair degree of unsaturation. They also contain a substantial amount of nitrogen and sulfur. The nitrogen appears to be derived from the fixation of atmospheric nitrogen during combustion.

Extensive studies by the petroleum and automotive industries have shown that there are a number of ways in which gasoline engine sludge may be reduced. Changes in engine design that insure more complete combustion of the fuel and that minimize contamination of the crankcase lubricant with fuel degradation products are beneficial. Fuel quality was found to be highly important. Volatile gasolines are substantially less prone to give sludge. Certain reactive components found in cracked naphthas appear to promote sludge formation, particularly those in the high-boiling fractions. Fortunately, these components can be modified by conventional treating methods or by Hydrofining. Improvement can also be obtained through the use of motor oil additives and certain synthetic lubricants.

Although previous investigators have assumed that conventional motor oil additives, "detergent-inhibitor additives," reduce low-temperature gasoline engine deposits by a dispersing mechanism, the present study indicates that their primary function is one of inhibition or repression of deposits formation. This was demonstrated by recovering quantitatively both oil-insoluble and oil-soluble fuel degrada-

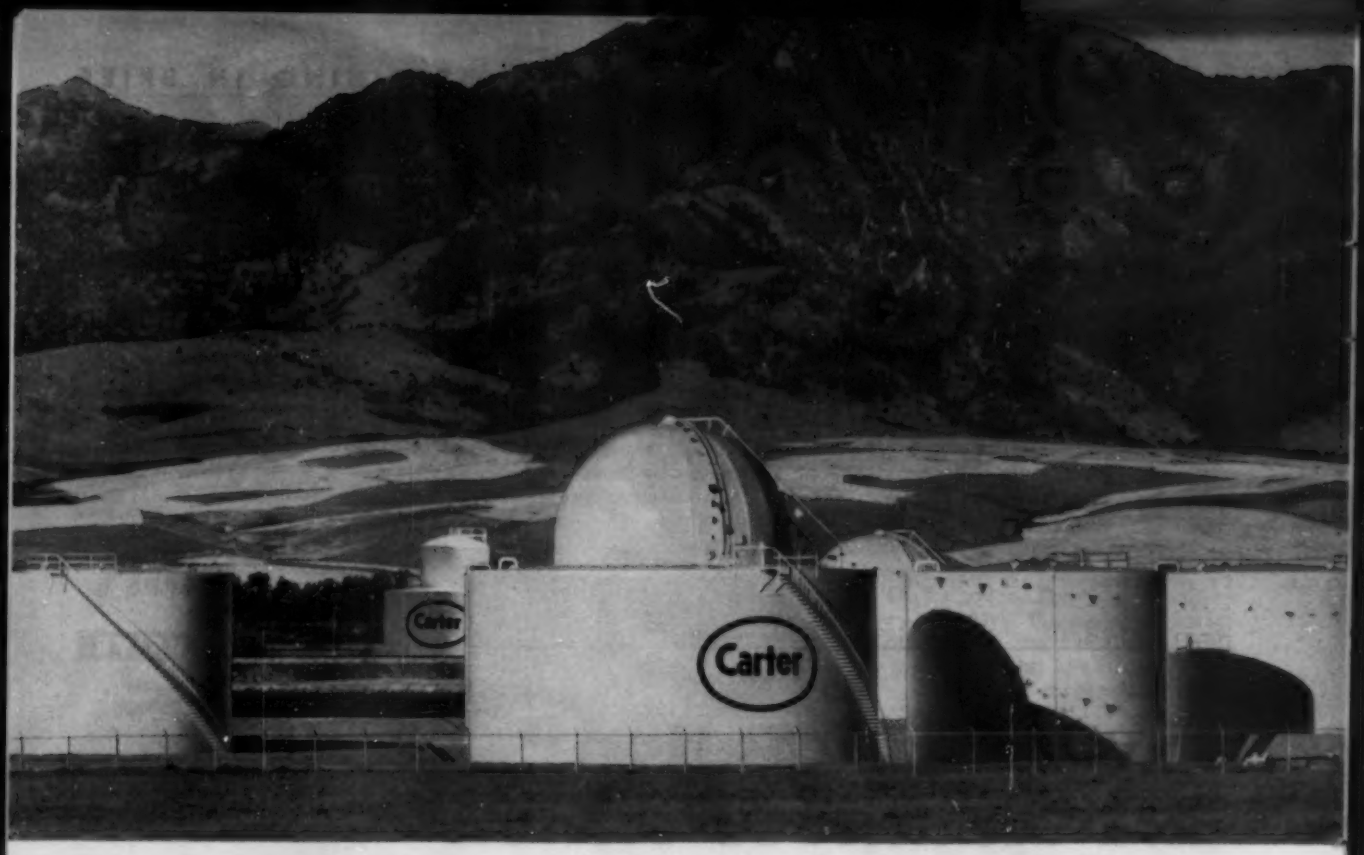
Fig. 1

Mechanism of Sludge Formation

Unburned Gasoline		
Partially Burned Gasoline (Liquid and Vapor)		
Oil-Soluble Precursors ("Red Oil")		
Acids	Moderate Temp.	High Temp.
Varnish		Lacquer

FIG. 1. Mechanism of sludge formation.

*Condensed by the authors from the paper, "Mechanism of Engine Sludge Formation and Additives Action," given before the SAE Fuels & Lubricants meeting, November 9, 1955.



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BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

tion products from the engine and drain oil in carefully controlled laboratory engine tests. An effective experimental additive (containing phosphorus, sulfur, and no metal), which shows greater inhibiting potency than commercial additives, has been prepared. It appears that with this additive, the reactions of the fuel degradation products to form oil-insoluble materials are stopped at the stage where the fuel degradation products are sufficiently volatile to be removed from the crankcase. As all of the additives studied that have sludge-inhibiting power (including commercial and experimental products) also are sludge dispersants, it appears that surface activity may be required to obtain inhibition. Experiments with full-flow oil filters also lend support to the hypothesis that heterogeneous reactions are involved in sludge formation.

A second experimental product, representing a new type of motor oil additive, has been investigated. This additive, which contains oxygen, nitrogen, and no metals, shows no inhibitting potency and prevents the deposition of engine sludge by a dispersion and solubilization mechanism. Although this additive reduces sludge formation in some areas, such as the push rod and rocker arm chambers, it is not effective in reducing piston ring zone deposits and crankcase sludge when high deposit-forming fuels are employed. The dispersing effect of this additive apparently results from its ability to convert normal low-temperature sludge into more easily dispersed form.

In the development of improved motor oil additives for low-temperature service, the inhibitor route appears to be the more desirable; that is, it appears advantageous to prevent deposits formation rather than to disperse or dissolve them after they have been formed.

The ability of some oxygen-containing synthetic lubricants to minimize sludge deposits appears to result from their ability to dissolve a substantial portion of the sludge component which normally acts as a precipitating agent for the total sludge rather than to a change in type of deposits produced.

A cyclic laboratory engine test is described which produces the same type of sludge deposits and in the same yield as obtained under very severe conditions in the field — stop-and-go, light-duty delivery trucks. By changing air/fuel ratios and proportion of time spent on idling in this laboratory test, it is possible to simulate the deposits produced under a variety of driving conditions. ★ ★ ★

O.K. BOYS BREAK IT UP!

Even after sedimentation, separation and chemical treatment of slop oils and refinery waste, you wind up with a knotty problem, that is, a highly stable interfacial emulsion. This is difficult to break, with too much oil in it to lose and too much contamination to allow discharge to waste. That's common knowledge.

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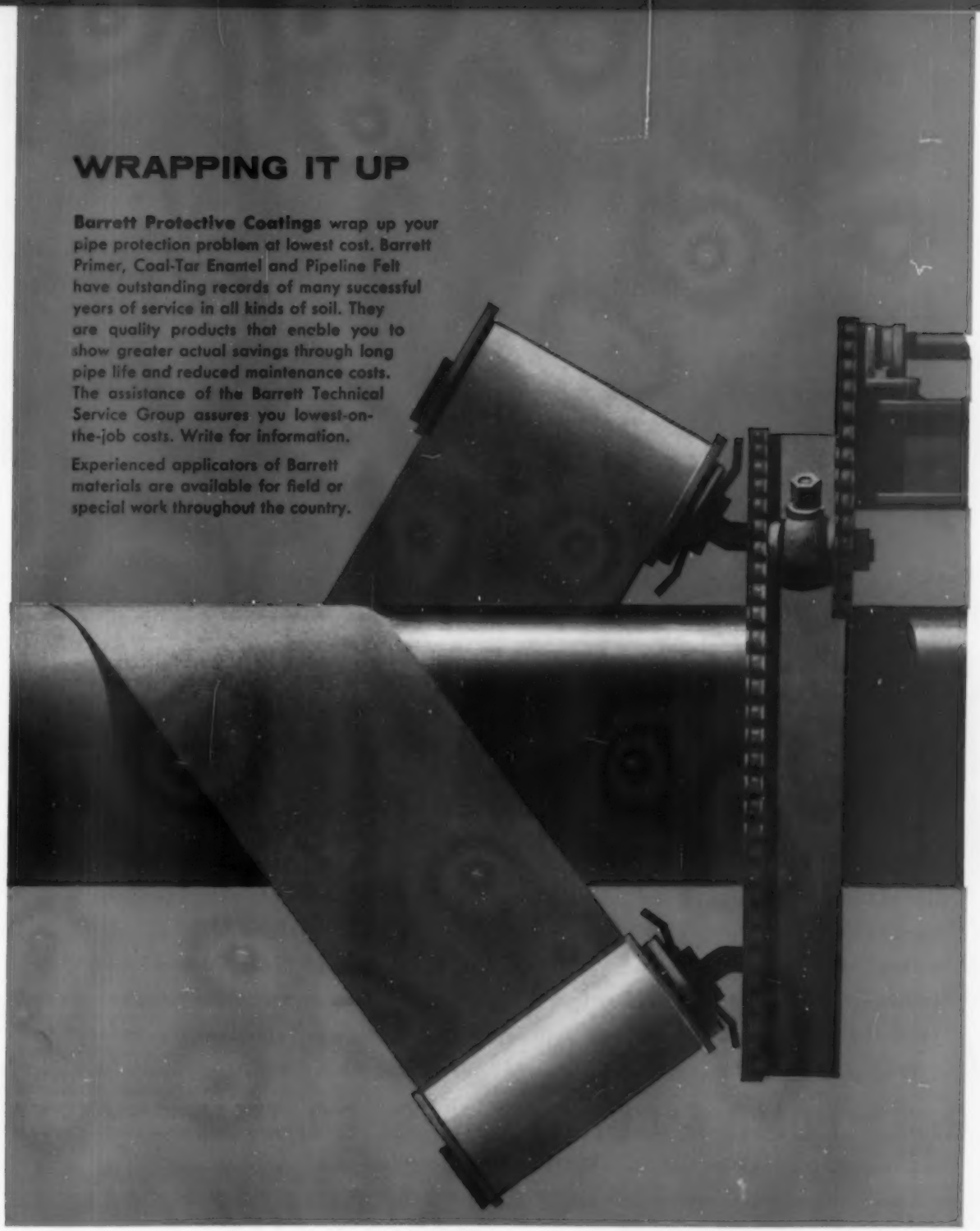

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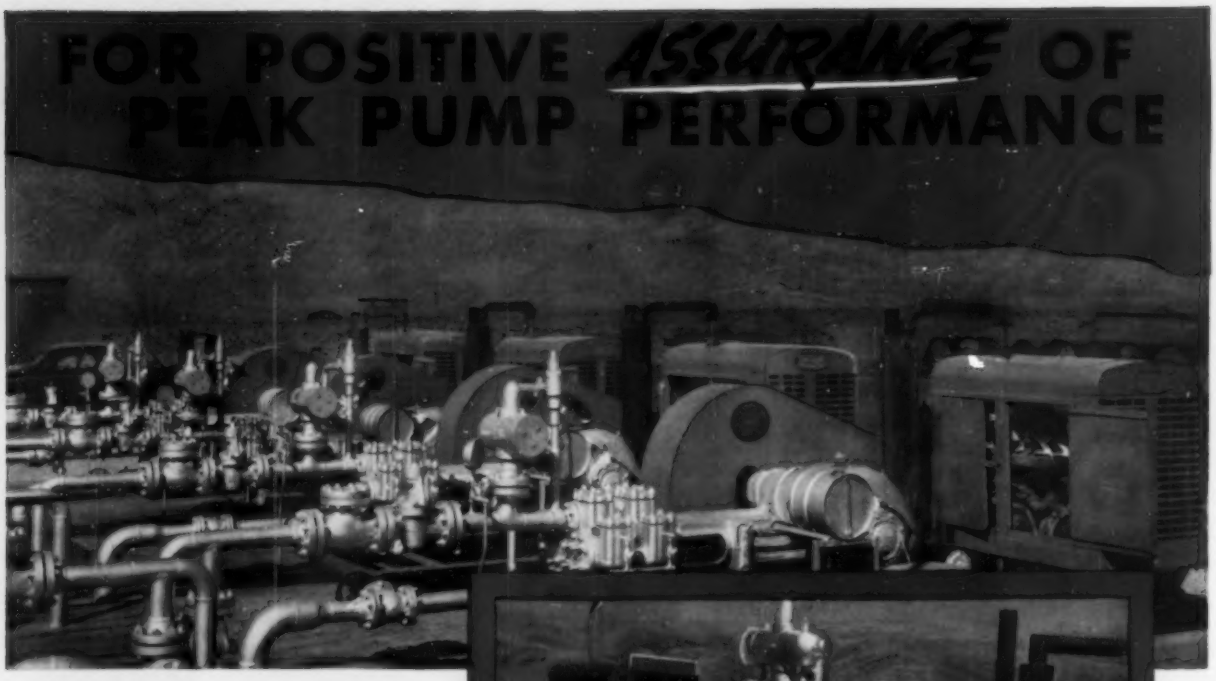

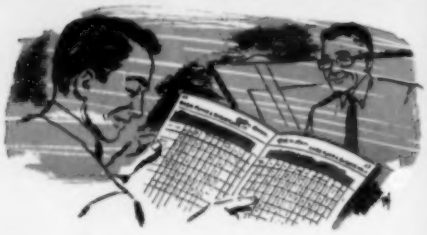

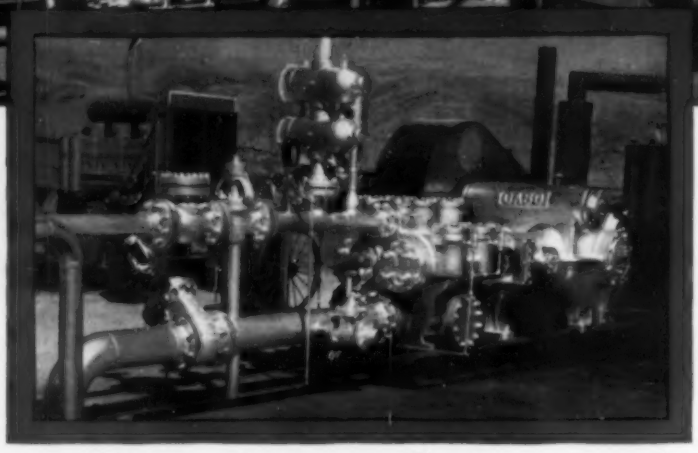

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PIPE LINE DEVELOPMENTS ★ ★ ★

Roundup of Current Planned and Proposed Construction

The following tables list the company, mileage, pipe size, and location of proposed pipe line projects — crude, products, and natural gas — reported to The Petroleum Engineer. Company addresses are given where furnished or known.

CRUDE LINES

Name of Company	Miles	Size	Location
Ar-Mex Pipe Line Company, Dallas, Texas	790	12-14	Guernsey, Wyoming to Coolidge, Arizona
Big Horn Pipe Line Company, Cheyenne, Wyoming	150	8	Ash Creek field to Service Pipe Line Company connection
Kaybee Pipe Line Company, Muskegon, Michigan	46	10	Griffith, Indiana to New Buffalo, Michigan
Michi, Inc., Detroit, Michigan	222	10	Highland, Indiana to Alma, Michigan
National Co-Operative Refinery Association, Kansas City, Missouri	30	8	Lyons to McPherson, Kansas
Offshore Gathering Company, Houston, Texas	364	20	Offshore line in Gulf of Mexico from Sabine Pass to Mississippi River
Pasotex Pipe Line Company, Houston, Texas	76	20	Wink to El Paso, Texas, to replace smaller system
Powder River Pipe Line Company, Casper, Wyoming	436	10-16	Williston Basin to Laurel-Billings, Montana, refining area
Richfield Oil Corporation, Los Angeles, California	4	10	Lines in Los Angeles area
Sinclair Pipe Line Company, Independence, Kansas	150	20	Mexia to Houston, Texas. Replacement of existing line
	12	6	North Madill field to Cumberland field terminal, Oklahoma
Stanmount Pipe Line Company	140	10	Beaver Lake field, North Dakota to Cromer, Manitoba station on Interprovincial Pipe Line
Tecumseh Pipe Line Company	—	20	New line between East Chicago, Indiana, to Cygnet, Ohio
Trans-Border Pipe Line Company	110	—	Skagway, Alaska to Whitehorse, Yukon, Territory
Trans-Prairie Pipe Lines, Ltd., Winnipeg, Manitoba	17	3-6	Lines in Cromer and Virden areas, Manitoba
Union Oil Company, Los Angeles, California	815	—	Considering line from shale oil plant at Rifle, Colorado, to Los Angeles area
U. S. Department of Defense	97	—	Crude line from Elk Hills Naval Reserve to Los Angeles

PRODUCTS LINES

Name of Company	Miles	Size	Location
Ar-Mex Pipe Line Company, Dallas, Texas	60	8	Coolidge to Phoenix, Arizona
	70	8	Coolidge to Tucson, Arizona
Bell Oil and Gas Company, Tulsa, Oklahoma	140	6-8	Ardmore to Cushing, Oklahoma
California-Oregon Pipe Line System, Crescent City, California	103	6	Crescent City, California to Medford, Oregon
Cosden Petroleum Corporation, Big Spring, Texas	100	6	Big Spring, to Abilene, Texas
Deep Rock Gas Company (LPG Line)	120	6	Tioga, North Dakota to U. S.-Canadian Border
El Paso Natural Gas Company, El Paso, Texas (LPG Line)	60	10	Farmington to Gallup, New Mexico
International Pipe Line, Inc., Minneapolis, Minnesota	132	8	Wrenshall to Minneapolis, Minnesota
Malco Pipe Line, Inc., Roswell, New Mexico	91	6	Prewitt to Albuquerque, New Mexico
	138	6	Artesia to Newman, New Mexico
Mayflower Pipe Line Company	400	10	New Jersey refineries to New England points
Moore-Stoner Company	200	6	Glendive, Montana to Minot, North Dakota
Phillips Pipe Line Company, Bartlesville, Oklahoma	50	12	Sweeny to Pasadena, Texas, refinery near Houston
Sioux Oil Company	50	6	Newcastle, Wyoming to Rapid City, South Dakota
Standard Oil Company (Ohio) c/o Sohio Pipe Line Company, St. Louis, Missouri	35.5	6	Mogadore to Girad, Ohio
Sun Pipe Line Company, Philadelphia, Pennsylvania	110	14	Marcus Hook, Pennsylvania to Newark, New Jersey
Texas Eastern Transmission Corporation, Shreveport, Louisiana	1168	16-20	Plans to convert the "Little Inch" line between Beaumont, Texas and Moundsville, West Virginia upon completion of new gas facilities. Has FPC apreval to abandon gas service from the "Little Inch"
Winnipeg & Central Gas Company, Winnipeg, Manitoba (LPG Line)	210	6	U. S.-Canadian border to Winnipeg (See also Deep Rock Gas Company listing)

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GAS LINES

Name of Company	Miles	Size	Location
Alberta Gas Trunkline, Calgary, Alberta	315	6-34	Gas gathering system in Alberta fields to serve proposed Trans Canada Pipe Lines
American Louisiana Pipe Line Company, Detroit, Michigan	117	22	Defiance, Ohio to Bridgman, Michigan
Arkansas-Louisiana Gas Company, Shreveport, Louisiana	76	24	Loops in Louisiana
Atlantic Seaboard Corporation, Charleston, Virginia	31	—	Parallel existing line in West Virginia and Virginia
	55	—	Interconnecting lines between Lost River station, Hardy County, West Virginia and Bickers station in Greene Virginia
Carolina Natural Gas Corporation	185	2-12	Lines in North and South Carolinas
Central Hudson Gas & Electric Corporation, Albany, New York	48	12	Albany to Kingston, New York
Central Kentucky Natural Gas Company, Charleston, West Virginia	21.1	20-24	New lines in Kentucky
Cities Service Oil Company, Bartlesville, Oklahoma	70	—	Gas gathering system on the Roberts Ranch, Midland County, Texas
Coastal Transmission Corporation, Dallas, Texas	562	22-26	McAllen, Texas to Baton Rouge, Louisiana
	272	Var.	Gathering lines in Rio Grande Valley, Texas
Colorado Interstate Gas Company, Colorado Springs, Colorado	110	6-8	Julesburg area to Denver, Colorado
El Paso Natural Gas Company, El Paso, Texas	413	34	Farmington, New Mexico to Topock, Arizona
Houston Texas Gas & Oil Company, Houston, Texas	961	12-20	Baton Rouge, Louisiana to Miami, Florida, serving Florida area with various laterals
Iroquois Gas Corporation, Buffalo, New York	36	Var.	Gathering and delivery lines in underground storage area in Chautauqua, Cattaraugus and Erie Counties, New York
Lone Star Gas Company, Dallas, Texas	230	30	Cotton County, Oklahoma to Fritch, Texas
	205	24	Snyder, Texas to Cotton-Fritch line
Michigan-Wisconsin Pipe Line, Detroit, Michigan	252	4-24	Loops on system in Missouri, Iowa, Illinois, and Wisconsin
Michigan-Consolidated Gas Company, Detroit, Michigan	25	12	Sparta to Muskegon, Michigan
Midwestern Gas Transmission Company, Houston, Texas	1112	12-24	Main line from U. S.-Canadian Border near Emerson, Manitoba-Noyes, Minnesota to Portland, Tennessee
	648	3-18	Laterals off main line to serve communities in Minnesota, North Dakota, and Wisconsin
Montana-Dakota Utilities Company, Minneapolis, Minnesota	41.8	12	Tioga-Beaver Lodge field in North Dakota to main transmission line
Morganfield Natural Gas Company	31	4-6	New lines in Kentucky
Natural Gas Pipe Line Company of America, Chicago, Illinois	350	20-26	Fritch, Texas to Wise County, Texas, through Southwest Oklahoma
Nevada Natural Gas Company, Las Vegas, Nevada	114	10	Loop of present system
Northern Natural Gas Company, Omaha, Nebraska	15	24	Loops on system in Nebraska
	28	24	Ogden to Redfield storage area, Iowa
	168	20	St. Paul-Minneapolis to Duluth, Minnesota and Superior, Wisconsin
	163	10-12	Main lines in South Dakota
	307	Var.	Branch lines in South Dakota, Minnesota, Iowa, and Wisconsin
Northwest Utilities, Ltd.	42	—	Bonnie Glen to Edmonton, Alberta
Offshore Gathering Company, Houston, Texas	364	30	Offshore gas line in Gulf of Mexico from Sabine Pass to Mississippi River
Pacific Gas & Electric, San Francisco, California	150	34	Loops on Topock, Arizona to Milpitas, California system
Panhandle Eastern Pipe Line Company, Kansas City, Missouri	20	24	Rolla to Hugoton, Kansas
	74	4-16	Loop lines and replacements on system
Permian Basin Pipeline Company, Omaha, Nebraska	19	16	Gathering system for 15 West Texas gas fields
Phillips Petroleum Company, Bartlesville, Oklahoma	22	20	Qyinduno field, Roberts County to Rock Creek, Texas, gasoline plant
Pioneer Natural Gas Company, Amarillo, Texas	261	3-22	New lines, loops, replacements and irrigation feeder lines in the Panhandle and South Plains of Texas
Pine Tree Natural Gas Company	204	—	Boston, Massachusetts to Bangor, Maine
Shenandoah Gas Company, Winchester, Virginia	39	3-8	Middleton, Virginia to Martinsburg, West Virginia
Southern Counties-Southern California Gas Companies, Los Angeles, California	236	30	Topock, Arizona to Newhall, California
Southern Natural Gas Company, Birmingham, Alabama	52	—	Loops on system in Alabama, Georgia, Louisiana, and Mississippi
Tennessee Gas Transmission Company, Houston, Texas	221	26-30	Loops in Ohio and Kentucky
	100	—	New gathering lines in Texas and Louisiana
	162	—	Loops in Kentucky, Ohio, and Pennsylvania
Texas Eastern Transmission Corporation, Shreveport, Louisiana	422	30	McAllen to Vidor, Texas
	530	30	Loops on system from Texas to New Jersey
	180	Var.	Supply, lateral, and gathering lines
Texas Gas Transmission Corporation, Owensboro, Kentucky	105	10-12	Eunice to Morgan City, Louisiana
	81	8-30	Loops on system
Trans Canada Pipe Lines, Ltd., Calgary, Alberta	2247	14-24	Alberta area to Toronto, Montreal, and other eastern Canadian areas
Transcontinental Gas Pipe Line Corporation, Houston, Texas	12.3	—	Gathering lines in Live Oak field, Vermilion Parish, Louisiana
	160	36	Additional construction planned for 1956 in Alabama,
	68	30	Georgia, South Carolina, North Carolina, Mississippi, Virginia, Maryland and Pennsylvania
Union Gas Company of Canada	180	—	Dawn Storage Field to Hamilton, Ontario
United Gas Pipe Line Company, Shreveport, Louisiana	63	—	Additional lines on system in Mississippi, Alabama, and Florida
United Natural Gas Company	50	12	Elk County to Jefferson County, Pennsylvania
Utah Natural Gas Company, Salt Lake City, Utah	40	16	Orem to Salt Lake City, Utah
Virginia Natural Gas Company	153	—	Buckingham to Richmond and Portsmouth, Virginia

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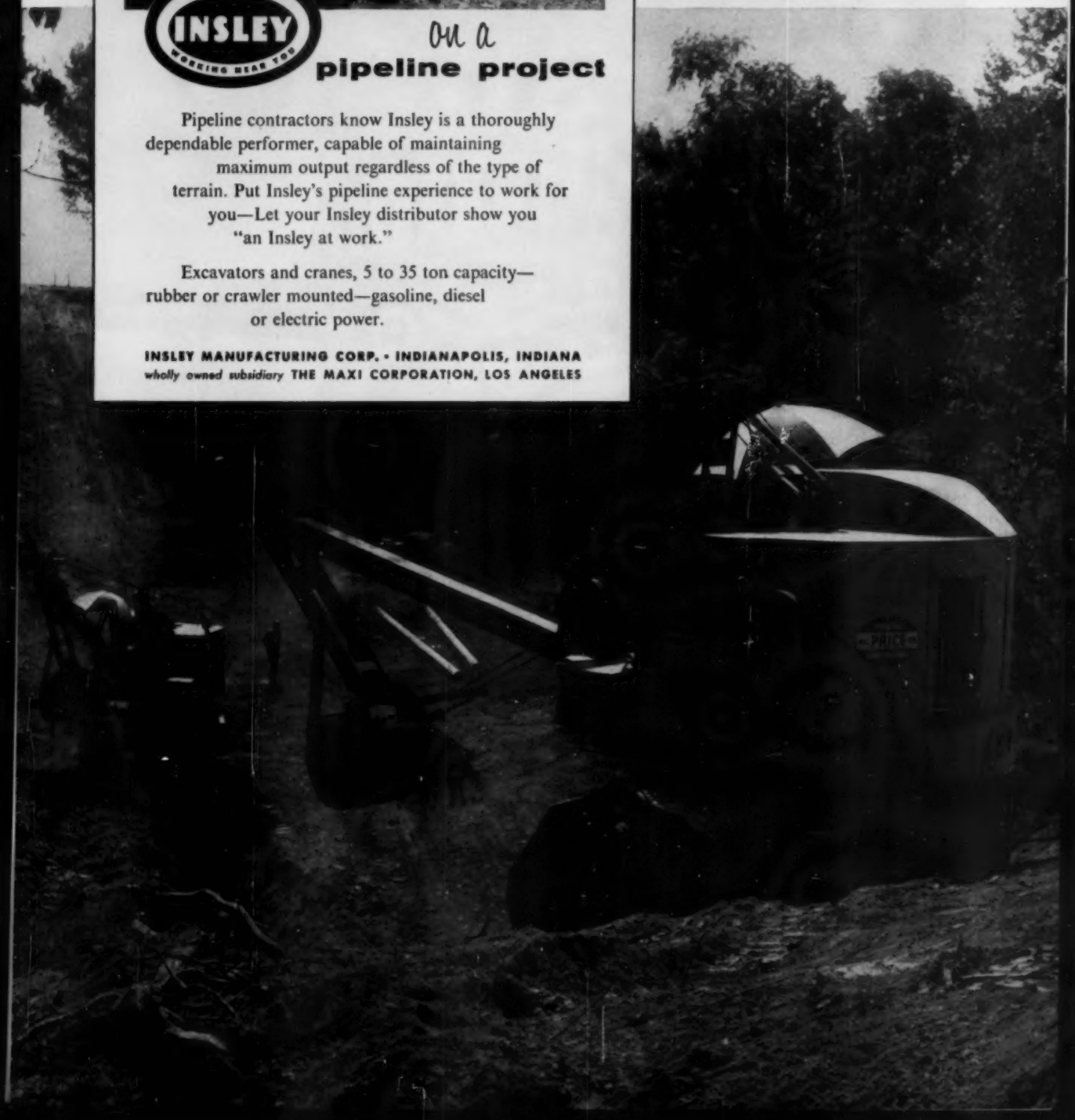

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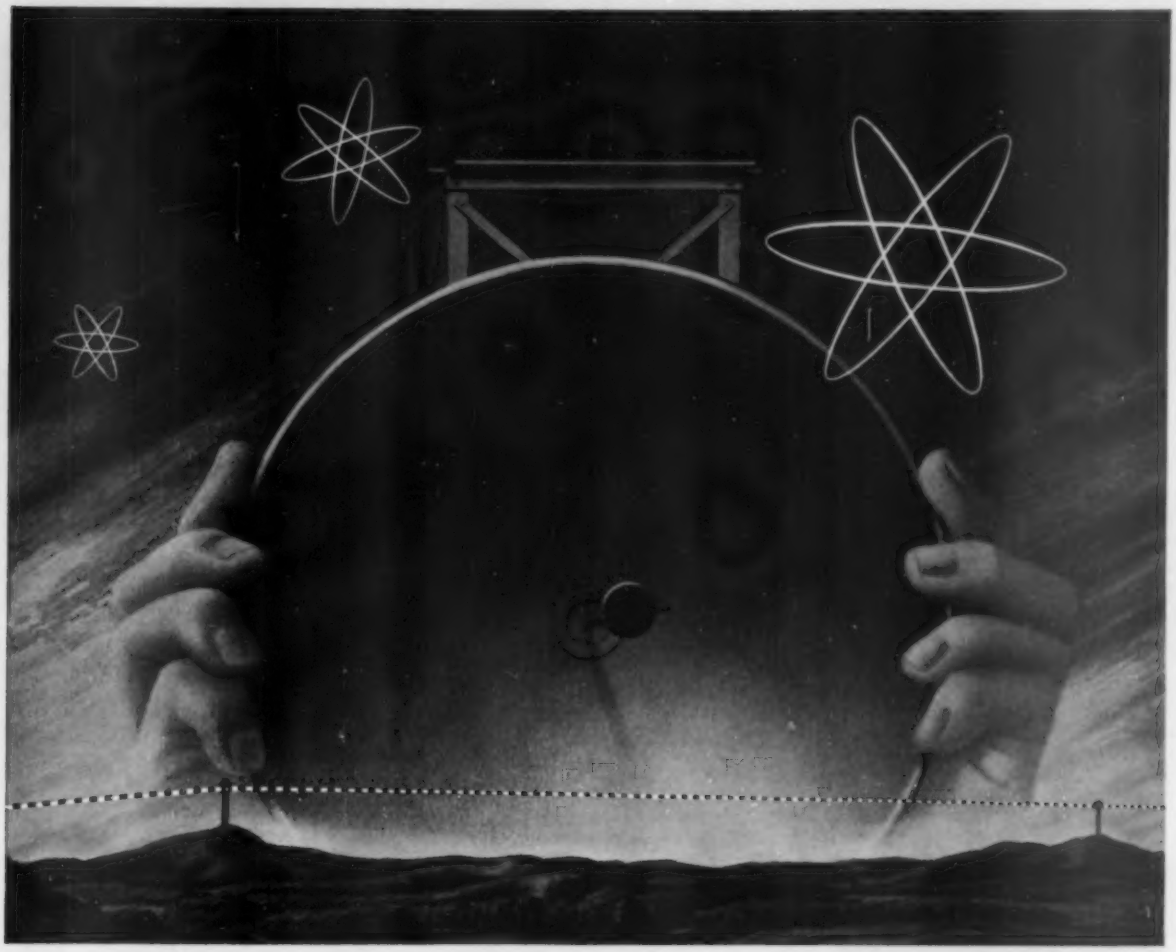

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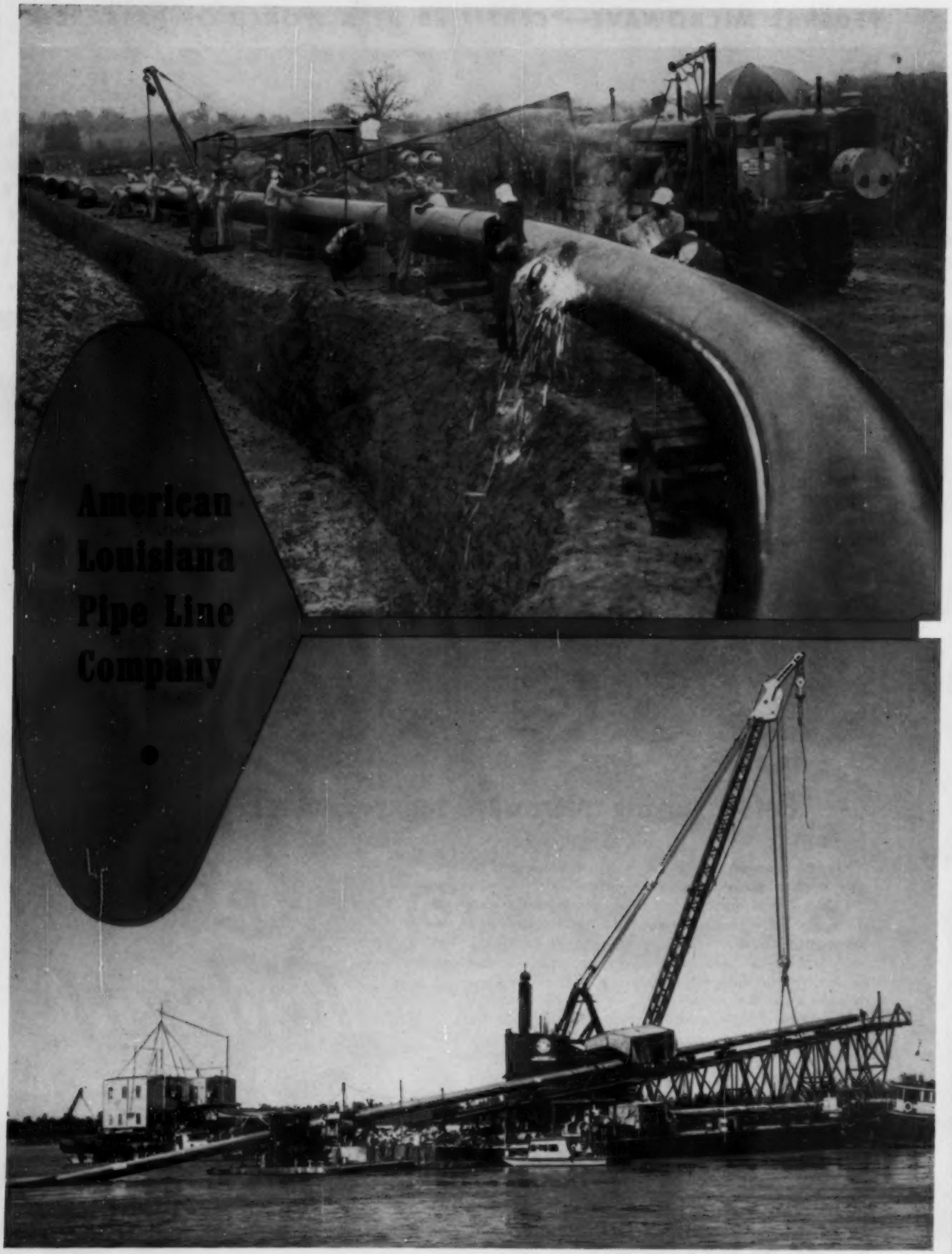
American
Louisiana
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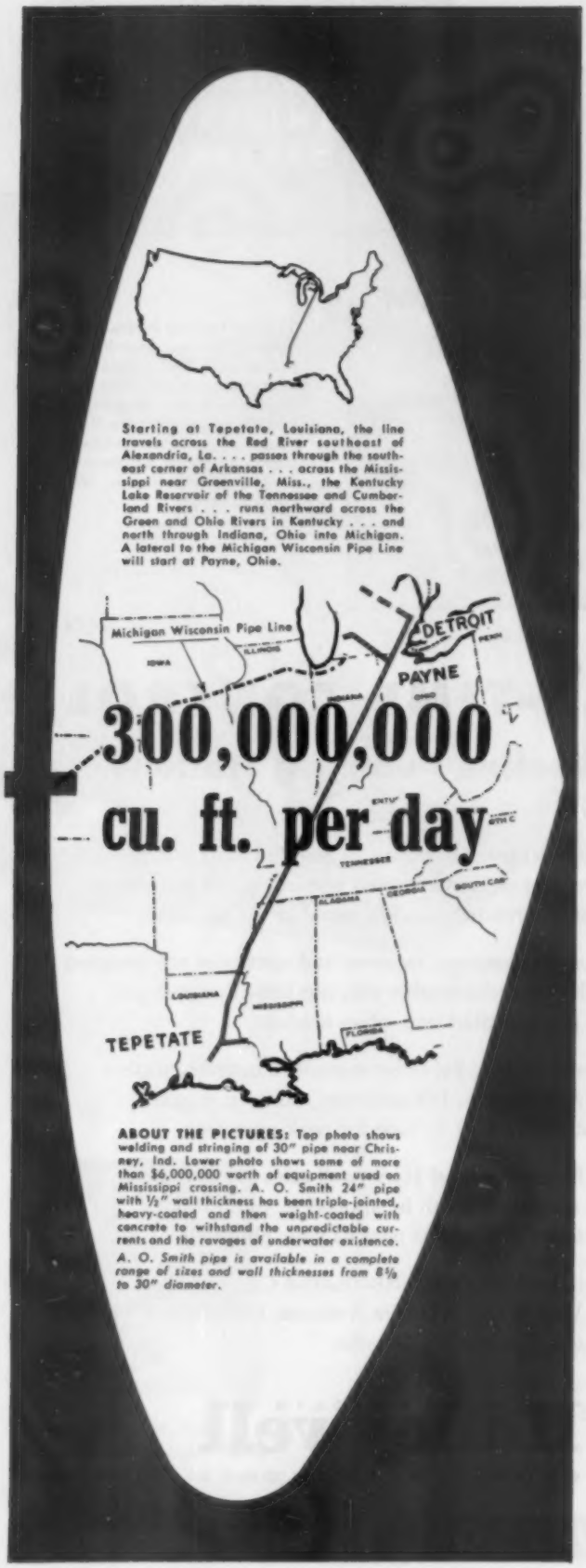
Company



Starting at Tepetate, Louisiana, the line travels across the Red River southeast of Alexandria, La. . . . passes through the southeast corner of Arkansas . . . across the Mississippi near Greenville, Miss., the Kentucky Lake Reservoir of the Tennessee and Cumberland Rivers . . . runs northward across the Green and Ohio Rivers in Kentucky . . . and north through Indiana, Ohio into Michigan. A lateral to the Michigan Wisconsin Pipe Line will start at Payne, Ohio.

ABOUT THE PICTURES: Top photo shows welding and stringing of 30" pipe near Chrisney, Ind. Lower photo shows some of more than $6,000,000 worth of equipment used on Mississippi crossing. A. O. Smith 24" pipe with ½" wall thickness has been triple-jointed, heavy-coated and then weight-coated with concrete to withstand the unpredictable currents and the ravages of underwater existence.

A. O. Smith pipe is available in a complete range of sizes and wall thicknesses from 8⅝ to 30" diameter.

793 Miles of A. O. Smith Line Pipe

THE new American Louisiana Pipe Line is being built to meet the tremendous requirements for additional supplies of natural gas in Michigan, Wisconsin and parts of Iowa and Missouri. When complete it will bring 300,000,000 cu ft of gas per day to these states. This capacity can be increased to 550,000,000 feet per day by the addition of compressor horsepower.

The main line will be 30" in diameter and extend 1000 miles from southern Louisiana to a connection with Michigan Consolidated Gas Company at Willow Run. It will cross 8 states and nine major rivers and lakes, marshes, swamps, rice fields, forests and the mountains of Tennessee, Kentucky and southern Indiana. Also, approximately 78 miles of 24" and 26" main line will be laid in southern Louisiana.

The pipe line system was designed by Ford, Bacon & Davis, Inc., and construction is being done by H. C. Price Company, Houston Construction Company and Brown & Root, Inc.

A. O. Smith Corporation played an important part in this new line by furnishing 758 miles, over 75%, of the 30" pipe from its Houston Mill, A. O. Smith Co. of Texas, and 35 miles of the 26" pipe, together with the 24" heavy wall pipe used for the major river crossings, from its Milwaukee Mill.

For almost 30 years A. O. Smith has held a high-standard of quality control and this quality control has been maintained at every step of the manufacturing process. That's why A. O. Smith pipe made and installed in 1928 is still in operation. That's why so much A. O. Smith pipe has been used in nearly every important high pressure line.

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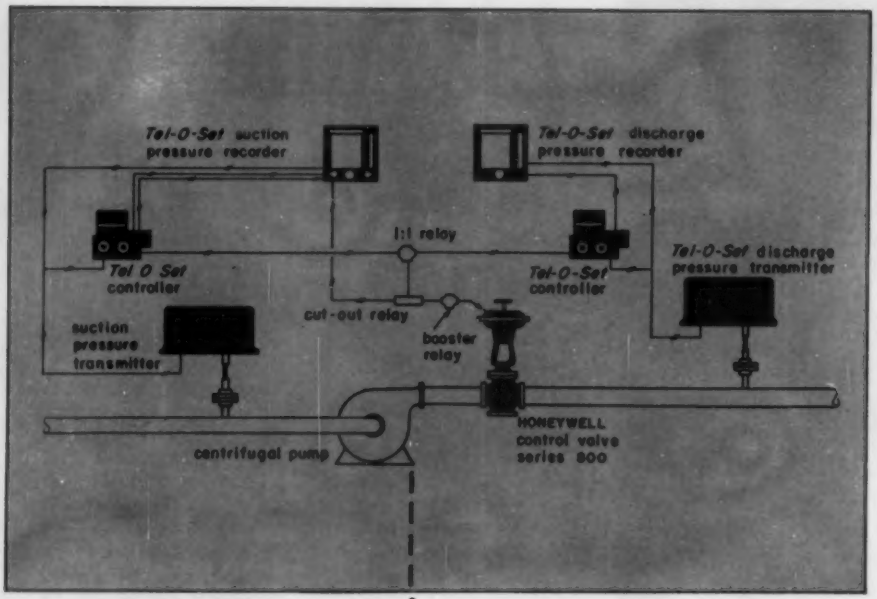


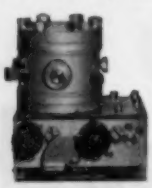
Typical *Tel-O-Set* instrumentation for a centrifugal pump uses a combination of transmitter, recorder and controller for both suction and discharge pressure. Systems are interlocked through a relay to operate a Honeywell Series 800 control valve.

***Tel-O-Set* transmitter**

sends air signal to recorder. It's fast, accurate, compensated for changes in ambient temperature and pressure. Zero and span readily adjustable.

***Tel-O-Set* recorder**

is accurate, sensitive, compact. All adjustments made from front of panel. Complete chassis is replaceable . . . no loss of control. 30-day chart record.



***Tel-O-Set* controller**

has fast response, is unaffected by vibration. Disconnects at turn of a single switch. Each sub-assembly is a precalibrated unit, interchangeable in seconds.

FULL-TIME CONTROL

...For Pipeline Pumping Stations

Put a *Tel-O-Set* control system to work on your pumps—and you're sure of uninterrupted service. When instrument maintenance is needed, the job gets done in seconds.

The reason: transmitter, recorder and controller are designed with quickly interchangeable unit sections. You just put in a new, precalibrated unit when needed.

In performance, too, *Tel-O-Set* miniature instrumentation leads in every respect. It's accurate, sensitive, rugged. It's exceptionally easy to tune for peak operation.

Find out from your local Honeywell sales engineer how *Tel-O-Set* instruments can be applied to your station. Call him today . . . he's as near as your phone.

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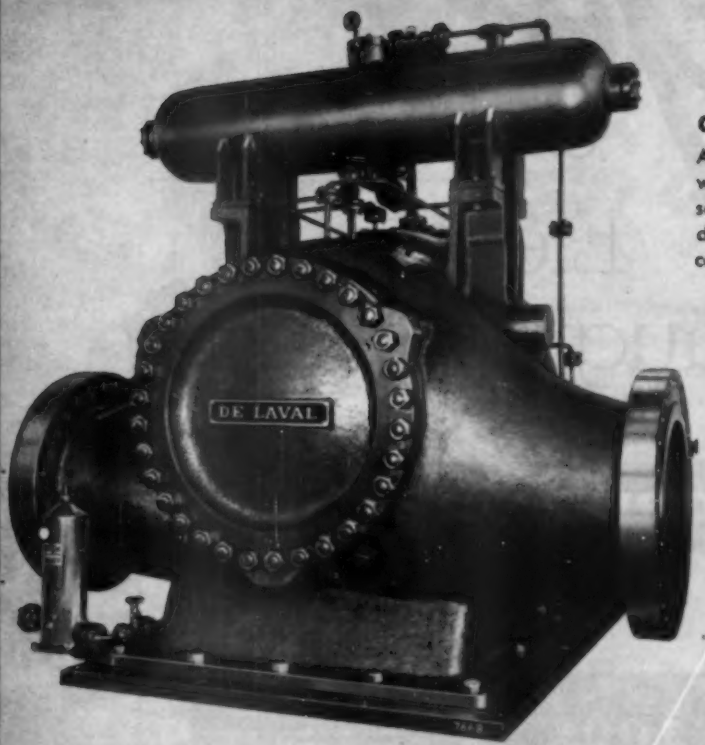
First in Controls

DE LAVAL
CENTRIFUGAL PIPELINE COMPRESSORS

come in two "packages" for easy installation



COMPRESSOR

A De Laval compressor with its emergency seal tank mounted directly on the compressor.

CONSOLE

The console contains the filters, motor-driven pumps, coolers, pressure switches, gauges and other accessories. It eliminates complicated piping on the packaged compressor . . . also serves as a protective cover for the equipment it houses.

Bulletin 503 gives data on De Laval centrifugal pipeline compressors. Write for your copy.

Designed in two packages, rugged De Laval centrifugal compressors offer many important engineering features. Among these are • high pressure contact shaft seal which eliminates gas leakage • heavy and rigid construction throughout • high load carrying capacity. The compressor and console arrangement makes De Laval centrifugal compressors easy to install—only simple low-cost foundations are required. De Laval units, totaling more than 280,000 horsepower, are now in operation on major pipelines.

DE LAVAL *Centrifugal Compressors*

DE LAVAL STEAM TURBINE COMPANY
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Here is complete AUTOMATION for your tank gauging. Five, ten, or fifty tanks – the New Gilbarco Electronic Tank Gauging System will handle the job accurately and automatically.

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UNION Centralized Transport Control can give you reliable remote control and indications for your entire pipeline from one central dispatching office. In effect, it permits the dispatcher to function as if he were actually present at each station under his control.

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UNION Centralized Transport Control can be used on a variety of pipeline layouts, gathering systems, tank farms and off-shore applications. It has been thoroughly proved in service and is backed up by our experience in centralized control covering more than 25,000 miles of long haul transportation. Write for information on your single or multiple station control requirements.

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These Bell System teletypewriters can be used for general communications and for dispatching and control between central point and remote locations.

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Let a Bell System communications engineer make a detailed study of your communications. Such a survey may save you time and money. There's no obligation.

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Bucyrus-Erie Dragshovels Save Trenching Time and Costs

YOU'RE OFF TO THE RIGHT START with a digging stroke that is powerful and steady so the operator can heap the dipper high. Power is concentrated at the dipper teeth for best penetration of even toughest material.

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FINISHING THE CYCLE, the dump is clean and trigger-fast. The dipper's high arch, smooth sides and rounded heel are designed for quick easy dumping.

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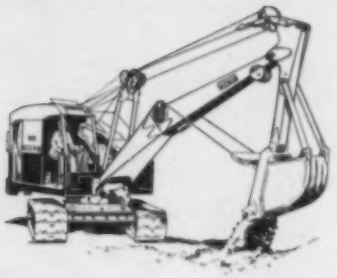
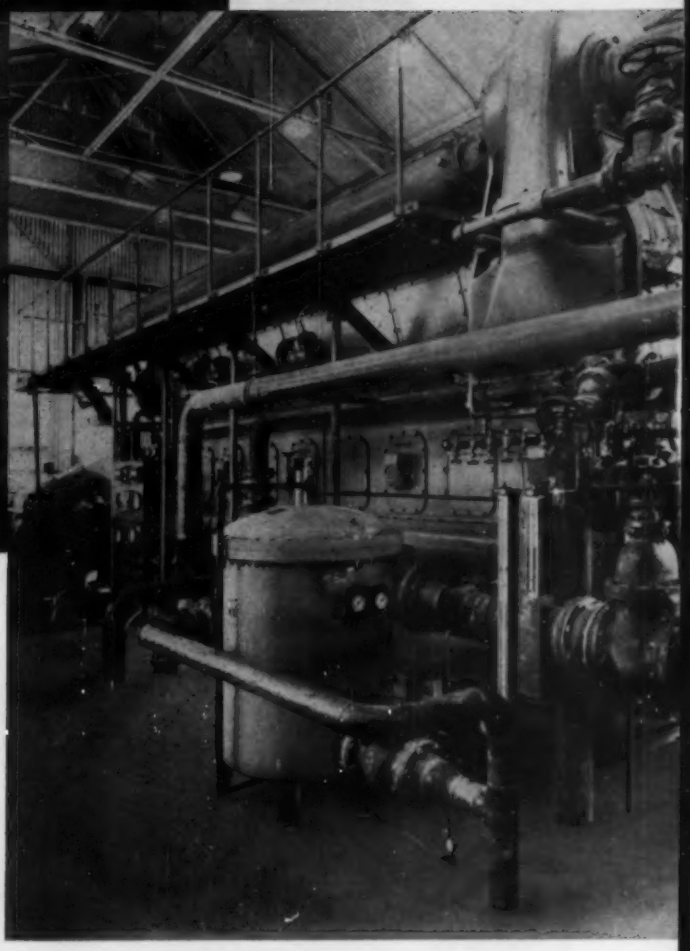


When you combine this kind of digging efficiency with the dependability that keeps maintenance costs way down, you have the machine you need for fast trenching in tough materials. See your Bucyrus-Erie distributor soon for complete details.

BUCYRUS ERIE
South Milwaukee Wisconsin

75 YEARS OF SERVICE to Men Who Shape the Earth

A ¾-yd. Model 22-B dragshovel, equipped with tractor-type treads, digs ditch for 24-in. natural gas pipeline in northern Pennsylvania.



"Satellite" pipeline station, remotely controlled, uses Western Gear two-stage high speed drive

REMOTE CONTROL operation from a point many miles away is a unique feature of the isolated Gulf-Interstate Gas Company's gas line pumping station near Stanton, Kentucky. Another modern feature is its two-stage high speed unit especially designed and manufactured by Western Gear, shown at upper left. This "custom-engineered" unit is driven by a Cooper-Bessemer 16-cylinder engine operating on natural gas from the pipeline. The engine speed of 360 RPM is stepped up by the high speed unit with a ratio of 16.8:1 driving the centrifugal compressor at 6,055 RPM. The entire pipeline station can be placed into operation and completely controlled by a telemetering system miles away.

Pipeline experts consider this station one of the most modern and advanced systems of its kind to date. Western Gear's long experience, dating back to 1888, made it the logical choice to design and build the high speed unit so essential to efficient performance of this significant installation. This experience is always available and Western Gear engineers are glad to help solve any problem involving mechanical power transmission equipment for the petroleum industry. Write General Offices, Western Gear Corporation, P. O. Box 182, Lynwood, California.

"The difference is reliability" • Since 1888

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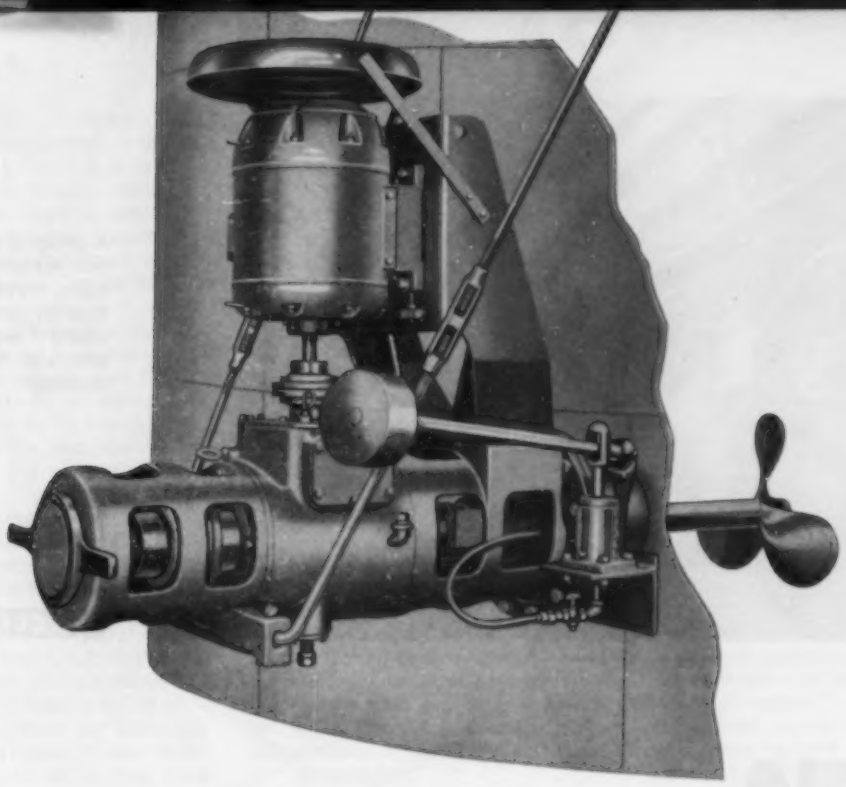

Sweep up EXTRA DOLLARS *off your tank bottoms*

You may save $1,000 a year controlling sludge this easy way

Don't let BS&W rob you of profits that should—and easily can—be yours.

It doesn't cost money to keep crude oil tanks clean by flipping a switch. It *pays.* Careful field tests, by a large pipe line company, show a direct, traceable saving of *$1,000 per tank per year.*

This figure indicates what you can save just by eliminating the costly job of cleaning out bottom sediment.

Tanks work harder, too

In addition, your tankage works at full efficiency when you need it. You add as much as 12% more tank capacity, without adding a single tank. You need never disrupt normal dispatching because tanks are "down" for cleaning.

You eliminate settling of refinable oil and wax. This can run as high as 4,000 barrels, in a 120-foot tank with 2-foot level of sludge. And you minimize the chances of corrosive sludge chewing holes around the tank bottom.

To get these savings, more than 50 independent pipe line companies and 35 leading producers and refiners choose LIGHTNIN Mixers for crude oil sediment control.

Simplest maintenance possible

You save more with LIGHTNINs, because maintenance is extra-easy. LIGHTNINs are built so they can *never* get out of alignment. Repacking is fast and simple, even with the tank full.

And for even bigger savings on upkeep, you can get the LIGHTNIN cartridge-type rotary seal that ends stuffing-box repacking forever.

You can get LIGHTNINs in a full range of sizes, from 1 to 25 HP, easily installed on old or new tanks.

Wouldn't you like to have specific facts on what *you'll* save with LIGHTNIN Mixers on your tanks? Your LIGHTNIN representative can give you these facts. You'll find him listed in Composite Catalog. Or write us today.

***Lightnin*® Mixers**

MIXCO fluid mixing specialists

***Left:* FASTER SERVICING.** You can repack a LIGHTNIN stuffing box from outside a full tank, without losing a pint of liquid. Shutoff device is out in the open, easy to get at.

***Right:* NO REPACKING** with this cartridge seal (optional on LIGHTNIN Mixers). It takes the place of a stuffing box; stops leakage; runs for years without adjustment; comes out in one piece for easy, rapid replacement if ever necessary.

Get these helpful bulletins on BS&W control and LIGHTNIN Mixers. Check, tear out and mail to us today with your name and company address. Free—no obligation.

- ☐ B-503 BS&W Control with LIGHTNIN Mixers
- ☐ B-104 Side entering mixers. 1 to 25 HP
- ☐ B-107 Data sheet for figuring mixer requirements
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MIXING EQUIPMENT Co., Inc., 127-d Mt. Read Blvd., Rochester 11, N.Y.

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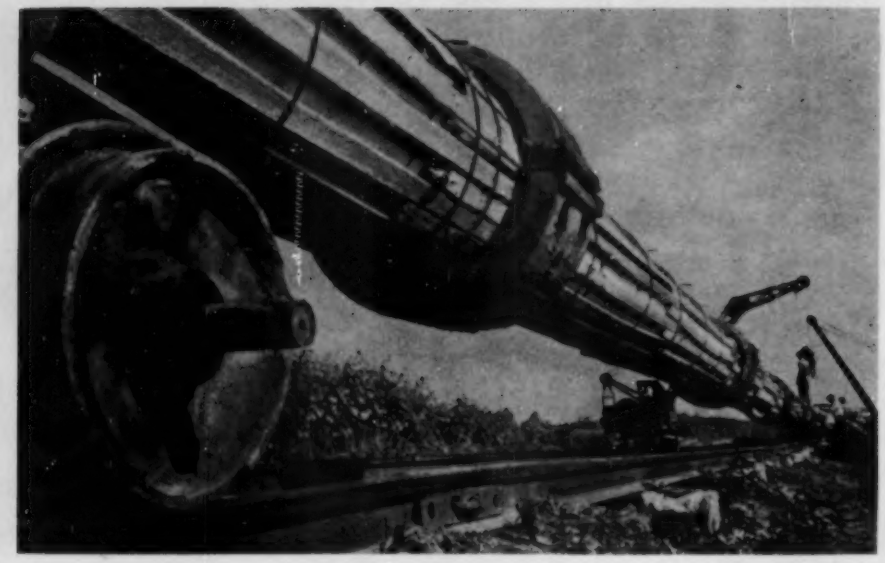


A string of pipe with cast-iron weights installed is being moved into a river from its position on shore where it was welded and otherwise made up for the crossing.

EXCLUSIVE

RUSSIA Discovers Pipelining

In announcing an expanded construction program, Soviet leaders claim some "new" methods that are "old hat" to U. S. pipeliners, but admit to "wasteful practices" and "inferior equipment"

Charles L. Adams

RUSSIA has called on its pipe line builders to create in the shortest possible time an enormously expanded oil and gas distribution system qualitatively equal to the best in the world.

Soviet leaders emphasize that under the Sixth Five-Year Plan (1956-1960) the nation's petroleum output is to increase 91 per cent to 135,000,000 metric tons (approximately 1,050,000,000 bbl) annually and natural gas production is to soar 288 per cent to 40 billion cubic meters (1412 billion cubic feet), annually. They want new pipe lines built not only to handle this huge new volume but to make up for past decades of industry backwardness.

Russia now depends almost entirely on railroad and water transportation to move crude oil and petroleum products long distances to consuming centers. In many cases, the newspaper Pravda points out, delivery by pipe line would cost only half as much.

Late last year, the USSR announced plans to put more than 5500 miles of new gas lines into operation by the end of 1960, including links from Stavropol in the northern Caucasus to Moscow, from Shebelinka in the eastern Ukraine to Bryansk, and from Dashava in the Carpathian Mountains to Minsk and Leningrad. The Russians have now added a vast oil and oil products pipe line construction program, which will connect the "Second Baku" fields west of the Ural Mountains with the important Siberian cities of Omsk, Novosibirsk, and Irkutsk, as well as provide new supply links in Moscow, Gorky, Molotov, Yaroslavl, Ryazan, and Bryansk.

The Soviet Union already has completed nearly 200 miles of its new 900-mile natural gas line between Stavropol and Moscow. It is Russia's first large-diameter, long-distance pipe line. About 80 per cent of the construction work on the Stavropol-Rostov section was mechanized, and work was carried on around the clock. The Russians admit, however, that they have encountered some difficulties on the project.

Need Better Pipe

Specifications for pipe used on the Stavropol-Moscow line permit a tolerance of plus or minus 3 mm (.118 in.) in diameter. "Unfortunately," says Pravda, "the most progressive method of welding —electrocontact — doesn't permit such a large tolerance.

"Metallurgical plants must be more accurate in manufacturing pipe so as not to delay technical progress in construction. They must, first of all, reduce diameter tolerance in their pipe to 1-1.5 mm (.039-.059 in.).

"It should also be noted that the Khartsyzsk Pipe Factory is delivering pipe to the Stavropol-Moscow project

that has a lengthwise weld seam 4 mm high on the surface instead of the permissible 2 mm (.07874 in.). In order to eliminate this factory defect, the pipe line builders have to double the thickness of insulation (coating) — necessitating the expenditure of millions of extra rubles, not to mention the extra work involved."

Pipe 720 mm (28.4 in.) in diameter is being used for the first time in Russia on the Stavropol-Moscow project. It is more than twice the diameter of the pipe used on the Saratov-Moscow line, which until last year provided the Russian capital city with most of its natural gas.

Equipment being used on the Stavropol-Moscow job includes: (1) A self-propelled machine that removes rust from the pipe, covers it with asphalt-mastic, and wraps it with a special paper tape; (2) an automatic electric welder that can weld 820 ft of prepared line pipe per shift; (3) a multi-bucket ditcher capable of digging 820 ft of 2-meter (6.56 ft) trench per hour, and (4) specially equipped 12-ton trucks with trailers capable of carrying three or four 130-ft pipe sections.

Over its entire distance from Stavropol to Moscow, the line will cross 22 large rivers, including the Don, Desna, North Donets, and Pakhra. It also will cross 43 smaller rivers, 250 ravines, 38 railroads, and 93 roads or highways.

The Soviet press reports that pipe will be laid at the highway and railroad intersections "by the so-called injector method, that is, without excavation from above." It says the "new" method not only is quick and inexpensive but permits pipe laying without disturbing railroad and automobile traffic.

Second section of the Stavropol-Moscow pipe line — the link from Rostov to Voronezh — is being laid in 1956. It will reach Moscow in 1957.

A. Kortunov, USSR minister of oil industry construction, warned recently in Pravda that the task facing Russian pipe line builders is so great that they must not rely entirely on their own experience. "The best achievements of foreign science and technology in this field must be studied and adopted," he declared.

Now Using Ditching Machines

Level of mechanization in the Soviet pipe line construction industry has risen sharply during recent years, and ditchers finally have replaced manual work in trench digging, according to Kortunov. But he noted that wasteful practices are still widely employed, and equipment is often inferior to that used abroad.

Listing Russian advances in pipe line construction, Kortunov was especially enthusiastic over new "semi-automatic and automatic devices" used in pipe welding.

"A new and progressive method of contact electric welding whereby adjoining pipe ends are welded in a short time without the need for electrodes or welding flux is coming into use. This method eliminates the difficult and demanding operation of overhead welding, now done by hand.

"Pipes are being cleaned, insulated (coated), and placed in the ditch by integrated, mechanized columns of mobile equipment. Bulldozers are used to cover the trenches.

"The welds are checked with radioactive cobalt gamma rays. Recently the Ministry of Oil Industry Construction's Scientific Research Institute developed a new magnetographic method of testing welds."

Kortunov reported that the rising level of mechanization permits Russian pipe lines to be placed in operation much faster than was the case several years ago. But, he cautioned, existing achievements in this field are no cause for complacency.

"A world's record was set abroad when a 1000-km (621.4-mile) oil pipe line (exclusive of work on the right-of-way) was laid in 61 days. Our Soviet builders could do as well with the present level of technology and with adequate use of resources."

Kortunov said that one of the basic technological problems facing the Russians is to achieve maximum capacity by increasing the diameter of pipe lines and by proper spacing of compression and pumping stations. He noted that a number of Soviet pipe lines are now ineffective because of the great distances between stations.

"A pipe designed for a pressure of 50 atm (735 psi) works at full load only at the beginning of the section near the compression station. Pressure decreases as the distance from the compression station increases, and the design capacity of the line is utilized only 20 to 30 per cent. Much more gas could be transmitted if the stations were closer together.

Stations Too Bulky

"Current designs for compression and pumping stations are too bulky, and their stone and brick construction requires much time and money. We should change to lighter structures with frames of precast reinforced concrete or light tubing and make use of heat-insulating materials.

"The method of inspecting pipe lines on foot or by automobile in order to determine their condition on the basis of external appearances is clearly outmoded. Such work must be replaced by automatic control."

Kortunov recalled that at the time the Saratov-Moscow gas pipe line was built, automatic devices could not be used widely. As a result, every compression station on the line employs about 100 men, and total operating personnel for the 500-mile line is nearly 1000. Designing of new pipe lines without using automatic equipment to replace a large number of maintenance personnel would be unthinkable, the Soviet minister declared.

Turning to communications, Kortunov said that every Russian pipe line is now required to have both telegraph and telephone lines. "However, modern technology permits reliable radio communication along the line. This requires much smaller investments,

Lowering pipe into trench on Stavropol-Moscow natural gas pipe line.

"Electrowelders" join lengths of pipe on Stavropol-Moscow gas line.

Two rotary-type ditchers dig trench on Stavropol-Moscow line.

speeds up construction, and cuts operating costs."

The Pravda article emphasized that improved pipe line laying depends in large measure on steel industry cooperation, which has not always been forthcoming.

"The government has decided that steel workers should supply pipe line builders with 12-m (39.37-ft) pipe lengths instead of the present 6-m lengths. This will cut in half the amount of welding now done along the line.

Longer Pipe Joints Urged

"But such a move is only the first step, and we must not stop here. A changeover to 18-m (69.05 ft) and even 24-m (78.74 ft) pipe lengths will permit a still greater reduction in welding work and speed construction.

"Existing conditions at the pipe mills make it difficult to produce longer pipe sections. Yet it would be easier, cheaper, and faster to provide for welding the sections together at the mills, rather than on the line.

"Steel workers could greatly facilitate pipe insulating by supplying pipes coated with one layer of insulation. Such a request by pipe line builders is minimal. Furnishing completely insulated pipe will permit dispensing with all insulating work during pipe laying operations."

Kortunov asserted that Russian pipe line builders are entitled to special help from Soviet machine building plants, although they have not been getting it. To date, he complained, pipe line construction organizations have had to design and even build for themselves in poorly equipped shops many types of necessary machinery and equipment.

"Gas lines particularly need turbine compressors rather than the present piston compressors, which are obsolete in design and inefficient. Builders need pipe-laying machines with a lifting capacity of 25 to 35 tons instead of those now constructed around the S-80 tractor. The latter cannot handle long sections of large-diameter pipe.

"Other countries are now making increased use of air testing of pipe lines, along with hydraulic testing. Production of high-pressure mobile compressors is required in order to introduce this progressive method in our construction work.

"Builders are also experiencing an acute shortage of special, high-capacity transporting units that can lift and carry pipe over difficult terrain in roadless regions.

"Our scientists have great opportunity for applying their discoveries in the pipe line industry. The technological development and industrial use of sufficiently durable, yet inexpensive, nonmetallic pipe would mark a tremendous advance in the evolution of long distance oil and gas transportation.

"Possibilities of using asbestos-cement pipe are also very promising. The USSR Ministry of the Building Material Industry is obligated to furnish such pipe for an experimental oil pipe line in the near future.

"Reducing the depths at which pipe is laid by from 0.8-1.2 meters (.263-3.94 ft) can save hundreds of millions of rubles during a single Five-Year Plan. The volume of excavation work would be drastically reduced, and capital repair costs would be cut. The Ministry of the Oil Industry must make the fullest study of this possibility.

"The USSR Academy of Sciences must also lend active cooperation to builders in selecting new types of durable and economical pipe covering that would permit insulating the pipe at the mills. Besides the presently used bituminous-base insulation, the use of plastic-base insulation, enamel insulation, and insulation with rubber additives is being considered." ★ ★ ★

EXCLUSIVE

Use of "Friction Transposition" method may make it possible to pull up to 50-mile lengths of pipe along bottom of sea in almost any depth of water.

New Method For Laying Underwater Pipelines

Donald M. Taylor
Gulf Coast Editor

COLLINS Construction Company has developed a new method of laying submarine pipe lines that may be the answer to the problem of laying long undersea lines in the deep waters of the offshore oil fields. The method is patterned after the "Continuous Marine Traffic" method that Collins used successfully in laying the twin crossings of the 4-mile-wide, 250-ft-deep Straits of Mackinac, and many other difficult crossings.

If the promises of the new method are fulfilled, 30 to 50 mile lengths of pipe will be pulled along the bottom of the sea in almost any depth of water. Morover, there will be no particular limit as far as diameter is concerned.

How the new method works: First the pipe is welded up in approximately mile long sections on shore, and the usual concrete coating is applied. As the sections are welded together and successively launched into the sea, pontoons are added so that the pipe will have 1 to 4 lb per foot of negative buoyancy (after the concrete has absorbed water). The pipe is pulled along the bottom by a barge, which winches itself along 12,000 ft or so of heavy anchor chain that has previously been laid along the path the pipe is to follow.

Anchor chain is leapfrogged ahead. As the pull barge reels in the anchor chain, it is transferred to a barge nearby. At intervals this anchor chain storage barge changes place with the anchor chain lay barge and continues laying the anchor chain at about the same rate as the pipe is being pulled along the bottom.

The anchor chain is the key to the entire operation. Its friction with the bottom soil provides the holding power against which the pipe is pulled. For most lines, Collins plans to use 2½-in. anchor chain, which weighs 53 lb per ft in water. Because of its shape, the chain bites into the ocean floor, and its holding power will almost always be at least equal to its own deadweight in water. As a matter of fact, the British Admiralty uses a multiplier of 2½ times the deadweight in water when calculating the holding power of chains and anchors. Of course, this factor is greatly dependent on the type of soil that makes up the bottom.

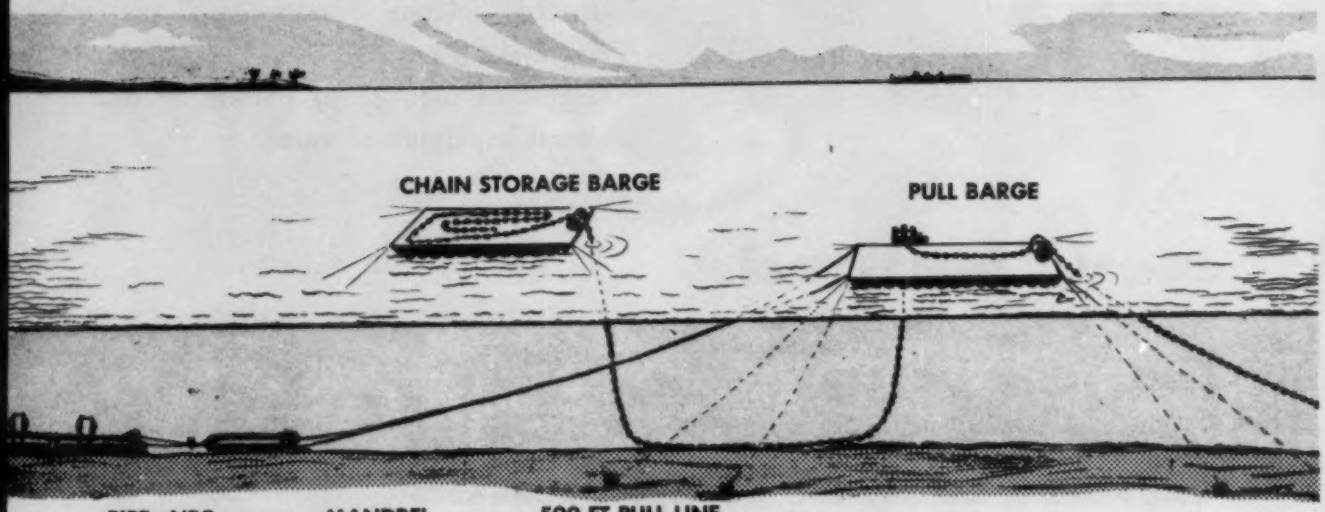
The safe working load of anchor chain of this type is rated at 492,000 lb, but this figure could be doubled by laying an additional chain. Seemingly, the only limiting factor so far as the length of pipe line that can be pulled by this method is the tensile stress that the owner will allow in his pipe. Collins anticipates that 30 to 50 mile pulls will not be uncommon.

One of the great advantages of this technique is that the pipe is in the calm undersea reaches at all times. Wind and waves on the surface have less effect on a line under the water than the normal currents and tides. So long as the barges can live in the sea above, the pipe line operations can continue without damaging the pipe, because the 500 ft or so of line between the pulling nose and the bull barge keeps most of the spring due to wave action from affecting the pipe.

One of the limiting factors of the operation is that for the most part, pipe lines must be laid in relatively straight lines. But, of course, most long lines at sea will be laid in relatively straight lines anyway as a matter of economy.

This method is an outgrowth of the Collins Continuous Marine Traffic method, which was used to span the Hudson and Niagara rivers and New York Harbor's Narrows as well as the Straits of Mackinac. In each of these instances, a heavy pulling cable was laid across the water and the pipe pulled across the bottom. Sufficient pontoons were added to the pipe prior to launching to give it a negative buoyancy of about 4 lb per ft once the concrete coating absorbed its load of water. The only trouble with this method so far as long lines are concerned is that the wire rope was more difficult to pull than the pipe. It tended to saw into the bottom, seeking its normal deep catenary. Dynamometer readings have shown that the more wire rope in the water the greater the pull, and naturally, the heaviest pulls came with the first launching, and the lightest with the last.

In every case, Collins was able to lay the lines straight, varying in most instances not more than 10 ft from the centerline of the route. Several means



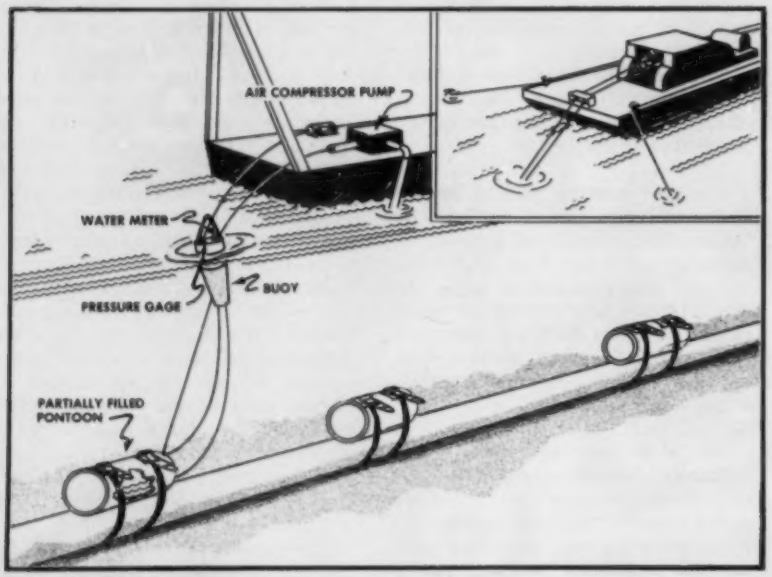
Method shown here for handling anchor

were used to keep this high degree of alignment. First, the pulling cable was laid straight and, in most cases, mandrels were attached in the line, and they tend to smooth a path for the pipe as the pull progresses. Second, the pipe is kept in tension during the pull, by a hold back winch and hold back clamps on the shore opposite the pulling winch. In swift currents (the Niagara River current was about 8 miles per hour) the pipe was given less positive buoyancy.

Many of these techniques will be incorporated in the "Friction Transposition Method." For one thing, the pipe will be held in tension during the pull, so far as practical. Where side currents are swift, the negative buoyancy will be increased, and in all instances, the anchor chain will be laid accurately along the right-of-way.

Collins also devised a means of lightening the line during a pull where necessary. Pontoons are spotted at key points along the line, partially filled with water to give a zero negative buoyancy. Leading from the pontoons are two rubber hoses attached to a buoy.

To lighten or heavy up the pipe line in the water, Collins moves a buoy equipped with a water meter and pressure gauge to the spot, ties on to the rubber hoses, and with an air compressor meters water in or out of the pontoon. Keeping in mind that the average weight of the pipe is in the neighborhood of 4 lb per ft it is easy to see that a slight amount of water removed from the pontoon can exert a great amount of upward force on the pipe. This equipment has been used on many Collins' jobs in the past.



Controlled buoyancy makes possible the laying of underwater pipe lines without interruption of marine traffic.

For the tie-ins at sea Collins has designed a tie-in barge that eliminates the usual difficulties associated with the task. The pipe is left in the water where, due to the pontoons and its own buoyancy, its weight is negligible. The two ends of the pipe are cut and placed in the well on the barge. The well is pumped free of water, and workmen add a 10 or 12 ft pup joint to make the tie-in.

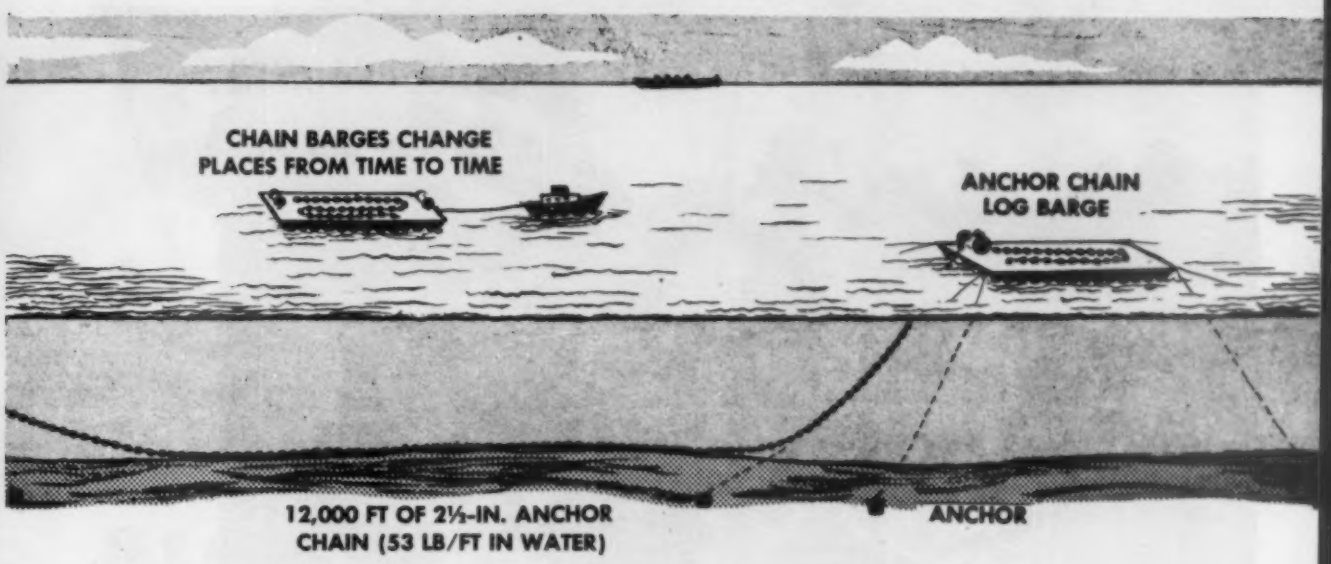
This barge can be counterbalanced with water during this operation.

Collins is planning to use this new method on a proposed line some time this year.

Friction Factors and Calculations

Based on experience and other data, here are some of the friction factors that are applicable to this operation:

1. Friction factor of the concrete coated pipe ..... = 10 per cent
   For safety factor multiply by 3 ..... = 30 per cent



chain is key to entire operation.

2. Friction factor of the anchor chain in water = 100 per cent of deadweight in water
3. Friction factor of the Collins launch way (rubber tires) by past dynamometer readings:
   (SLF) Starting load factor.....= 0.0240 × deadweight
   Moving Load factor (MLF).....= 0.010 × deadweight

Here are some calculations that are applicable to a 30-mile-long 16 OD × ½ wt pipe line of seamless tubing. The pipe is to be coated with coal tar, etc., and a concrete coating, which brings its weight to 197.41 lb per lineal ft in air. During this operation, sufficient pontoons are to be added to bring the pipe's negative buoyancy to 4 lb per foot in water. The pipe is to be launched 5280 ft at a time.

The initial pull is calculated to be:

5280 × 197.41 lb per ft = 1,042,325 lb deadweight.	
0.0240 starting load factor, Collins launchway (one mile)	lb 25,016
Mandrel and pontooned pull chain	5,000
Restraining holdback	10,000
Initial starting load	40,016

As the end of the first string approaches the tie-in station on the launchway, the following calculations should be nearly correct:

Launchway friction: 200 ft × 197.41 = 39,482 lb × MLF 0.010	lb 394
Friction of nose mandrel and 500 ft chain (pontooned)	5,000
1000 ft of pipe @ 1 lb negative × moving load factor = 1000 × 30 per cent = 300 lb pull	300
4280 ft × 4 lb = 17,120 × MLF 30 per cent	5,136
Restraining holdback	10,000
Total moving pull required first string	20,830

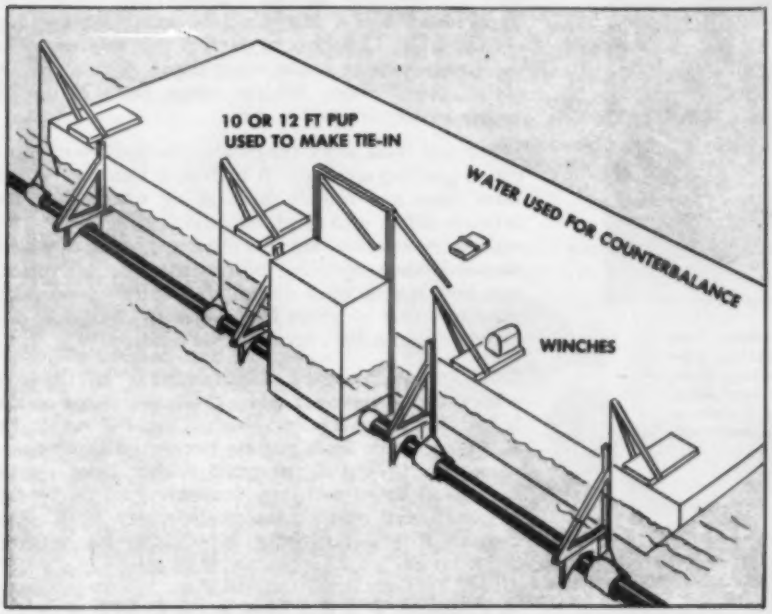
Of course, the heaviest pull required will be the starting load of the last string of 29 miles of pipe in the water, and 5280 lineal ft of pipe on the launchway. 5280 lineal ft × 197.41 lb per ft = 1,042,325 × SLF 0.0240 =

Starting pull required (launchway) one mile	lb 25,016
Friction nose mandrel and 500 ft pontooned chain	5,000
1000 ft of pipe at 1 lb negative (see above)	300
153,120 ft of pipe at 4 lb neg. =612,480 deadweight × SLF 30 per cent =	183,744
Restraining holdback	10,000
Total pull required to start last string	224,060

Pulling the last few feet of pipe the dynamometer readings should be:

	lb
Launchway friction	0
Friction nose mandrel × 500 ft connector	5,000
158,400 ft of pipe at 4 lb neg × 30 per cent =	190,080
1000 ft pipe at 1 lb neg × 30 per cent =	300
Restraining holdback	10,000
Total pull required end of line	205,380

Admittedly this figure can range 50 per cent either way. ✱ ✱ ✱



Underwater tie-in barge.

CROSS-COUNTRY at 25 feet per minute

Mobile, utility-size Trenchmobile on rubber tires travels 12.6 m.p.h. — does trouble-shooting, pipe reclamation. It digs main lines, gathering lines, or laterals, 8 to 16 inches wide — 5 feet deep. (Parsons heavy-duty line also includes 3 sizes of ladder-type Trenchliners, full crawler mounted.)

. . . . . PARSONS CO., Newton, Iowa . . . . . .

Send us bulletins on: ☐ 88 Trenchmobile® ☐ 150 Trenchliner®

NAME_____

TITLE_____

COMPANY_____

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CITY, STATE_____ PG80 PE

On main-line trenching, or as an auxiliary unit for opening laterals, Parsons 150 wheel-type Trenchliner sets a fast pipeline pace. 30 digging speeds, from 12 inches to 25 feet per minute, give top trench production at every depth, width, and in all soil conditions. Widths range from 16 to 26 inches — depths to 5¾ feet.

Speed and wide work range are combined with precision grading accuracy. A hydraulic ram on vertical mast raises and lowers the digging wheel — gives infinite depth selections, maintains close grade tolerance. A separate ram tilts the mast, balances wheel forward when traveling or trailer-loading. Notice, too, how simple mast design eliminates unnecessary superstructure — gives low overhead clearance, improves accessibility, operator visibility.

Dual-purpose friction clutch drives the digging wheel, and automatically protects against shock loads. Cast-steel buckets with "Tap-In" teeth are interchangeable with gumbo buckets. Shiftable, reversible conveyor discharges to either side. Standard, 16-inch, grouser-type crawlers provide plenty of sure-footed traction for cross-country work. Ask Parsons distributor about it, or send for catalog.

PARSONS COMPANY

NEWTON, IOWA • *(Koehring Subsidiary)*

Special manifold and control system are features of installation on Champlin products line.

Main-line pumps are 9-stage verticals powered by 125-hp motors.

P 615.51

Station Designed for Two-Way Pumping

Frank H. Love
Editor, Oil, Gas & Products Pipelining

WHEN Champlin Refining Company's Enid, Oklahoma, products pipe line station became inadequate due to system growth, it was replaced recently by a new installation of special design.

The present station is capable of delivering products simultaneously north and south, and this is what the former smaller station could not do. Ability to meet requirements which means pumping 500 bbl an hour in each direction, was effected principally by design of the manifold and the control system, although other features contributed almost as importantly.

The north section of the Champlin pipe line system extends some 517 miles through the northern part of Oklahoma, entirely across Kansas in a south-north direction, northeast through Nebraska, across the southeast tip of South Dakota, and terminates at Rock Rapids, in the northwestern part of Iowa. Along the route, deliveries are made at the Hutchinson, Kansas, and Superior and Columbus, Nebraska, terminals. Booster stations at Tescott and Bluff, Kansas, assist the flow. The south section covers a much shorter distance, ending at Oklahoma City, a distance of approximately 82 miles.

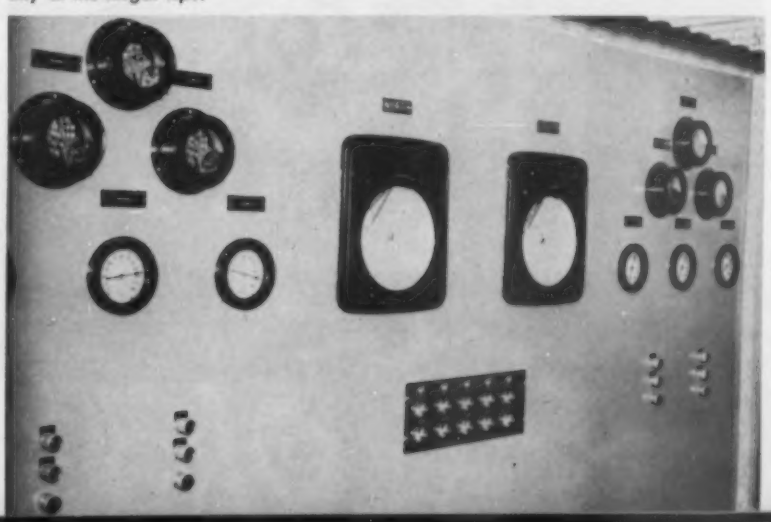
Six finished products — Ethyl gasoline, regular gasoline, No. 1 and No. 2 diesel fuels, kerosine, and tractor fuel — are handled in the system. Such a variety of traffic, and the fact that it goes in two directions at the same time, necessitated the installation of an elaborate manifold system to assure that all products meet specifications and that there is no commingling. A further feature is the fact that north and south pumps, or combinations of pumps, can be interchanged in case of emergencies.

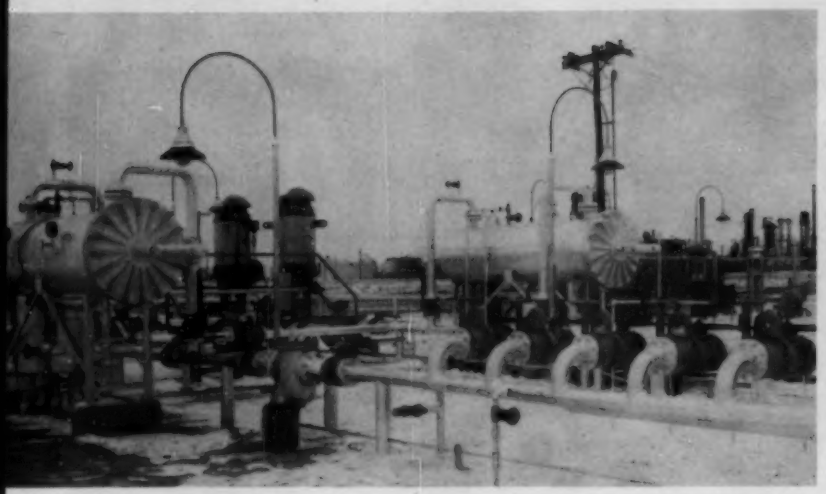
This station is situated near the Champlin refinery on the outskirts of Enid, and products are moved from refinery storage tanks to the receiving manifold at the station through approximately 12 miles of 8-in. lines laid on concrete stanchions. Transfer pumps at the tanks consist of vertical, single-stage centrifugal units having a capacity of 1000 bbl an hour and are driven by 30-hp motors. A booster pump of this type is set at each tank, controlled remotely from the station office. Pressures at which products are delivered to station pump suction range from 40 to 90 psi, depending on the liquid level in the tanks.

The suction manifold is equipped with plug valves and spool-type line-blinds. The latter provide positive shut-off and prevent commingling of products.

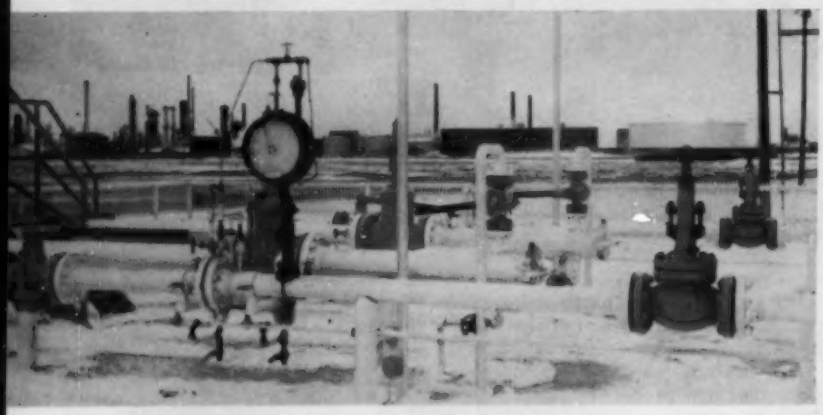
Upon arrival at the station, flow is first through 80-mesh screen strainers, one on the south line and one on the north, to remove large foreign matter. Next, "hay tanks" or separators take the smaller material and water from the stream. The flow is then measured

Control panel in pump house, where engineer has the station's operations literally at his finger tips.

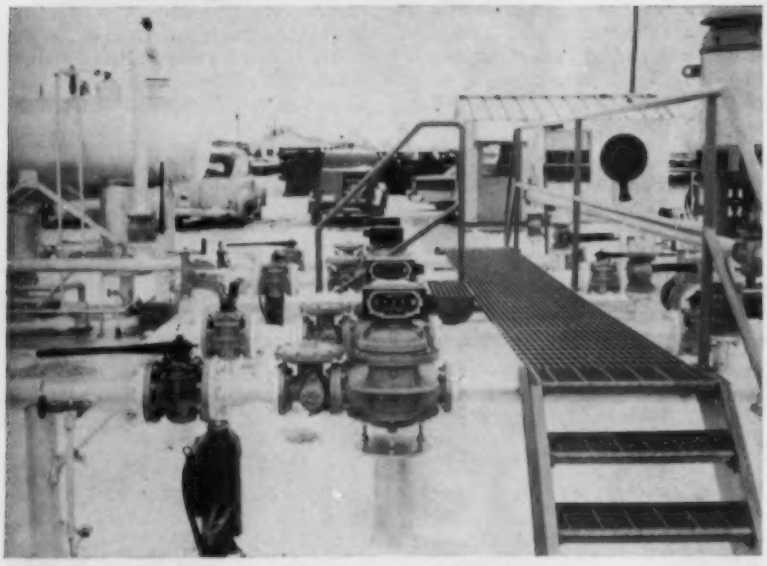




"Hay tanks" for removing solid matter and water from products stream. Spool-type blinds (at right) on manifold provide positive shutoff and prevent commingling of products.



Check valves, throttling valve, and orifice meter run.



Dual meters are provided on both the north and south lines.

by dual meters on both the north and south lines. Each meter will measure the full flow. The north and south sets of meters are manifolded, and should either get out of order, measurement can be made through the other set.

Main-line pumps consist of four 125-hp, 9-stage vertical units. The pumps operate in series and discharge into the north line at a maximum pressure of 1000 psi and into the south line at 800 psi. The pumps also are manifolded and so can be used to pump either north or south.

Controls

Main-line and transfer pumps are controlled from pushbuttons on the control panel, situated in the pump house. Starting and stopping of motors is over a carrier frequency. Suction, intermediate, and discharge pressures, flow rate, and all safety devices (high and low-pressure mercoids) are piped and wired into the control panel.

A safety control switch is provided on the suction side of the No. 1 pump. Should the booster pump stop, this control will shut down the No. 1 pump. Another safety control switch on the discharge of the No. 1 pump protects the unit from excessively high or low discharge pressures. A similar control on the discharge of the No. 2 pump protects the unit on high or low discharge. Glycol seals are used in all lines from the control panel to the operating units.

A meter for recording flow and line pressure is installed on a 3-in. orifice plate behind the last pump. The recording chart is a part of the control panel.

Tankage

Tankage consists of five 55,000-bbl tanks, one each for regular and Ethyl gasoline, kerosine, No. 1 and No. 2 diesel fuel, and one 10,000-bbl tank for tractor fuel. To prevent picking up water that has settled to the bottom of the tank when pumped out, each tank has been provided with a suction trough and a water drawoff sump.

The trough is 10 ft long by 16-in. OD, with a blind flange on the end away from the tank side and small drain holes in the bottom. The sump is made of 24-in. diam pipe, 2 ft deep. This is welded into the bottom of the tank and thus extends 2 ft below it.

Water is drained from the sump through a 2-in. pipe. To prevent the 2-in. drain line from freezing after water has been bled from the sump, a ¾-in. copper tubing extends from the tank to a connection with the drain line outside the tank. After water has been bled from the sump, the drain line is closed by means of a valve, and product from the tank enters the line through the copper tubing. In this manner, freezing is avoided. ★ ★ ★

Reputation Built on Performance
Experienced crews, adequate equipment, and modern know-how — a combination you can't beat for speed, quality, and complete satisfaction. Our reputation for top-notch, on-the-job performance, at bid price, eliminates undue construction costs and unnecessary delays. Our contract obligations are fulfilled, and pipeline operation begins, ahead of schedule.
H.B. ZACHRY CO.
PIPE LINE DEPARTMENT
TRANSIT TOWER, SAN ANTONIO, TEXAS

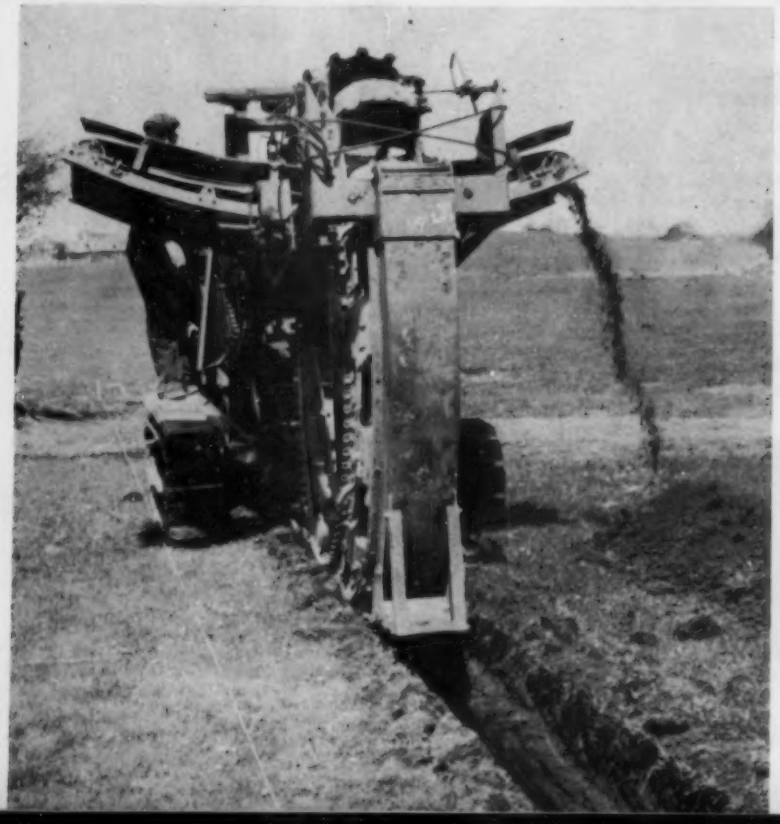
The first ditcher stripped the topsoil to a depth of 9 in. A second ditcher trenched to a depth of 3 ½ to 4 ft.

P 623.

Welsh Gas Line Laid by American Methods

Transmission system ties together and serves a group of 25 gas distribution outlets.

Typical Welsh terrain through which the pipe lines passes. The pipe is being cleaned and primed.



Walter Sekules

STATESIDE know-how and equipment were primary factors in construction of a 130-mile 12¾-in. gas pipe line in North Wales, Great Britain completed early this year. This is the first time that American pipelining methods were used in the British Isles for a gas system. It will supply gas to some 25 distribution outlets serving 70,000 consumers, and provides for future expansion.

There are good reasons why up-to-date pipelining could not be carried out in Britain on any major scale until now. There is no major oil producing industry, no natural gas production, and, until a few years ago, manufactured gas was distributed mainly on a local basis by small units. Transmission lines that were constructed often passed through thickly populated areas

EXCLUSIVE

Another New Big Production Pipe Team from Allis-Chalmers

HD-16 tractor with hydraulic torque converter drive

TRACTOMOTIVE HEAVY-DUTY SIDE BOOM

150 net engine hp
Weight — 57,840 lb, tractor and side boom with full counterweight
77,500-lb lifting capacity at 4-ft overhang

Sharpen your pencil and bid for profits with this new Allis-Chalmers HD-16 tractor-side boom team. Here is a combination that gives you lifting capacity, stability and safety to take on big pipeline jobs—yet keeps operating costs down.

NEW ALLIS-CHALMERS ENGINE

This Allis-Chalmers heavy-duty diesel engine offers quick starting with smooth, long-life performance. High power output with big reserve capacity means low maintenance costs.

PROVED TORQUE CONVERTER POWER

The HD-16 gives you the outstanding advantages of proved torque converter drive — smooth, cushioned power for tractor and boom, most shifting eliminated so operator can concentrate on pipe work. With full horsepower available at all times, the HD-16 matches speed perfectly to slow-moving clean-prime, dope-wrap machines, even on steep grades.

UNMATCHED STABILITY IN ITS SIZE CLASS

Eighty-four in., center-to-center tread width, up to 24-in. track shoes and long track with seven heavy-duty truck wheels give this crawler tractor balance and stability to boom out the big loads. Double reduction final drives and smooth, clean bottom construction provide extra clearance to skim over obstacles. And with torque converter permitting tractor to ease smoothly into motion, there's no tendency for tracks to dig in.

EASY TO OPERATE AND SERVICE

With direct electric starting on diesel fuel, hydraulic, finger-tip steering, self-energizing brakes and comfortable foam-rubber seats, operator gets more work done. You save on maintenance time with such outstanding features as simplified adjustments, fewer lubrication points and 1,000-hour lubrication periods for truck wheels, idlers and support rollers.

SAFE, HUSKY SIDE BOOM

Side boom features drop-proof safety counterweights; internal expanding brakes, fully enclosed from dirt and moisture; easy-working, convenient controls; and constant mesh transmission. It's built to take full advantage of the HD-16's big lifting capacity.

BIG OUTPUT — ALL THE WAY

The HD-16 is newly engineered throughout to give you big safety factors and long life in every component. This tractor, whether equipped with dozer or side boom, will give you big production under tough, as well as average, conditions — help you hold down costs on every job you bid.

ALLIS-CHALMERS, CONSTRUCTION MACHINERY DIVISION, MILWAUKEE 1, WISCONSIN

ALLIS-CHALMERS

where mechanical methods could not be used.

Following nationalization of the industry after the war, scattered gas systems in each part of the British Isles were consolidated under area gas boards. The North Wales gas system was constructed to tie together local gas distribution systems in the area.

Gas is being collected from three plants:

1. Manufactured gas from a new gas works at Maelor.
2. Coke oven gas from the John Summers steel mill at Shotton.
3. Reformed methane, drained from the coal seams of Point-of-Ayr colliery. This is the first time in Britain that reformed methane is being supplied to a gas system.

Adoption of American pipelining methods for the Welsh project resulted from the U.S. tour of a study group of the Organization of European Economic Cooperation (OEEC) two years ago. W. T. Hird, distribution engineer of the Wales Gas Board, was a member of this group. He returned to Wales so impressed by American pipelining that he persuaded his board to adopt these methods for the construction of the North Wales system.

Costain-John Brown Company took the contract and called in Williams Brothers of Tulsa, Oklahoma. H. W. Franks, European and Middle East representative of Williams Brothers, and a team of nine U.S. specialists advised Constain-John Brown, helped to organize the operations, trained British operators, and supplied American tools where needed.

According to Franks, it was possible to use standard American pipelining methods on the whole, but some had to be modified to suit local conditions.

Trenching was performed in two stages. The lead ditcher removes the top 9 in. of soil. The second ditcher then cut the trench to a depth of 3½ to 4 ft. This method is a departure from customary practice. In rocky ground, the trench was cut by backhoes after first blasting.

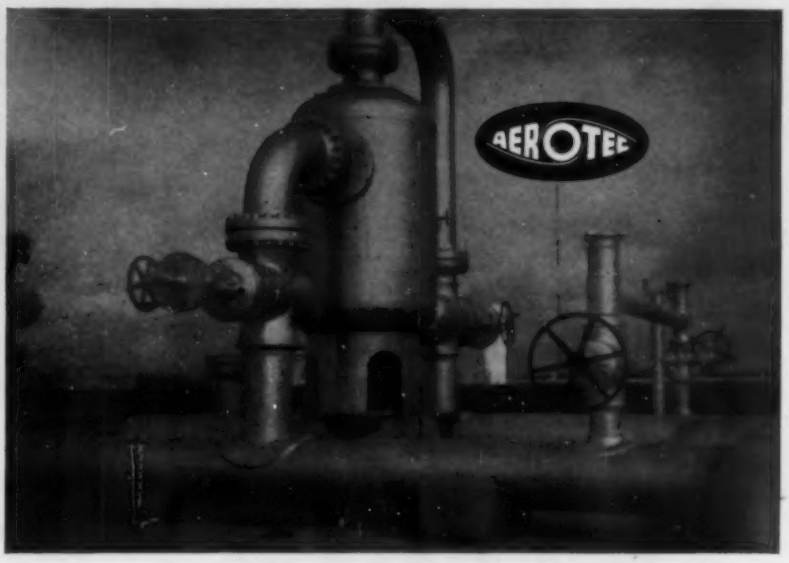
Great care was taken to insure proper backfilling and cleaning-up, as much of the transmission line passes through agricultural country. Filled-in soil was consolidated by running one track of a bulldozer over the line. Topsoil was carefully spread back over the banks and hedges remade, stone walls rebuilt, and any necessary cultivation and crop planting done.

After backfilling, the pipe was tested. The line operates initially at 40-50 psi, but was designed for a considerably higher operating pressure, which will be utilized at a later date. Therefore, the pipe was tested with compressed air to withstand a pressure of 250 psi. Where the line passes through thickly populated areas, the test was made to 300 psi. These tests were followed by stringent long-period leak tests at 100 psi.

Soil resistivity tests were made during construction, and cables welded to the pipe at 400-yard intervals. Several months after the date of final construction, cathodic protection will be finally installed. The need for this waiting period is because electrical current resulting from welding may remain in the line for a considerable period, affecting the current drainage tests on which the protective plan is based.

In many respects, pipe line construction in Wales presented greater difficulties than through desert terrain. For one thing, it took three fulll years to negotiate rights-of-way with Welsh landowners.

With American pipelining methods, the line was laid in approximately 10 months. By conventional British construction methods, it might have taken another two years or longer, according to contractors. * * *



Here's a dry Gas Scrubber that will

take a 100% overload without loss of efficiency

Aerotec Gas Scrubbers enjoy a wide acceptance with leading pipeline companies. This recognition is the result of many advantages:

1. **Dry Delivery**
   Aerotec Gas Scrubbers deliver gas free from dust and liquid carryover. They employ no fluids in the scrubbing process.
2. **Overload Provision**
   Aerotec Gas Scrubbers will operate for a period at 100% overload without loss of efficiency.
3. **Compactness**
   These units are a fraction of conventional scrubbers in size.
4. **Manifolding**
   Aerotec Gas Scrubbers lend themselves to convenient parallel operation up to any capacity. Any unit may be removed from the line without affecting gas delivery.
5. **Simplicity**
   Aerotec units are simple in design and practically foolproof.

Why not check with our project engineers? They are experienced in methods of removing foreign matter from gas.

Project Engineers **THE THERMIX CORPORATION** Greenwich, Conn.
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Manufacturers
THE AEROTEC CORPORATION
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NOW!

Instant Hydraulic Control of Conveyor Speed and Direction

Only **Gar Wood Buckeye** *has it!*

LIVE HYDRAULIC WHEEL HOIST, TOO!

Positions digging wheel faster, more accurately. Independent of all other operations. Operated from the seat by simple, one-hand controls.

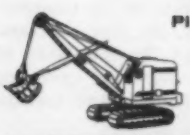
Live hydraulics in new job-proved Buckeye ditchers make conveyor control far easier and faster than ever before. From the seat, the operator merely touches a lever for instant conveyor adjustment to handle any volume of spoil. Three discharge speeds in either direction meet every conveyor need. And, Gar Wood's exclusive hydraulic conveyor drive is completely independent of any other function. No complicated shifting . . . no need to stop digging wheel or crawlers. Maintenance is easier, too. No complicated drive transmission to adjust and repair.

All three of these new Gar Wood-Buckeye models—the 305, 307 and 308—have this and many other important features. For complete data and specifications, call your Gar Wood-Buckeye dealer or write direct to: Customer Service Department, Gar Wood Industries, Inc., Wayne, Michigan.

GAR WOOD INDUSTRIES, INC.

Wayne, Michigan • Findlay, Ohio

Plants in Wayne and Ypsilanti, Mich.; Findlay, Ohio; Mattoon, Ill.; Richmond, Calif.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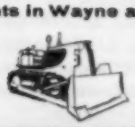
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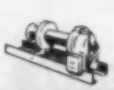
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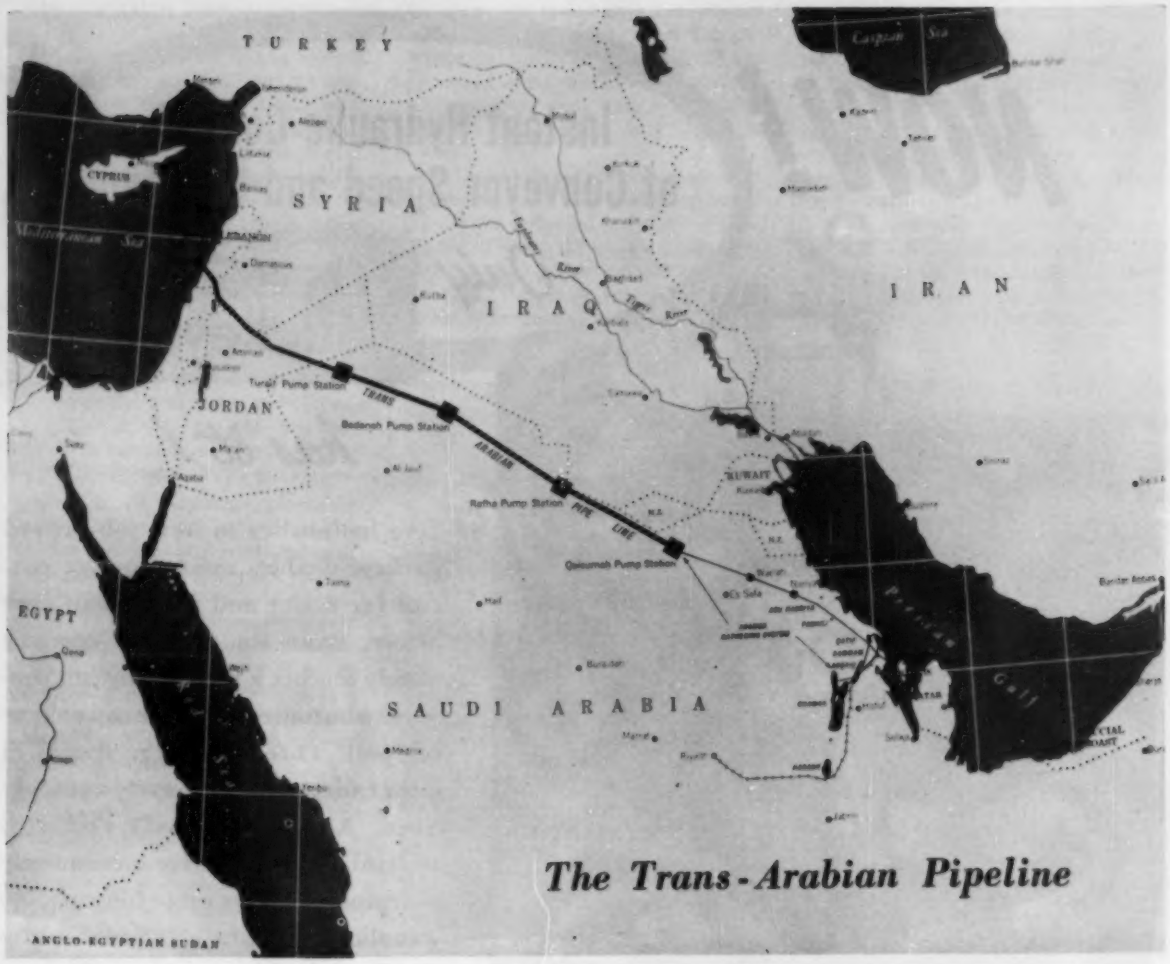

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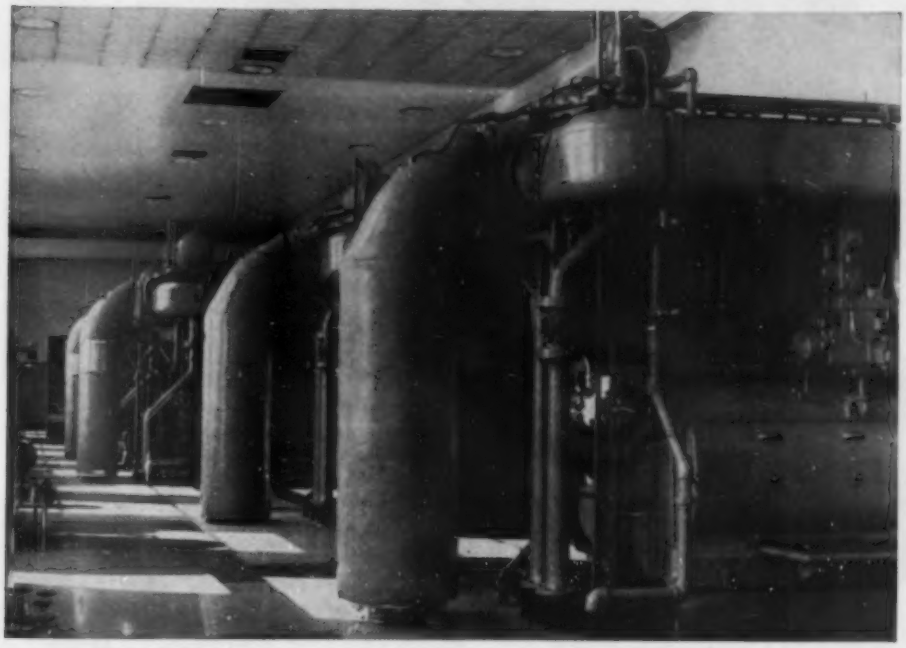

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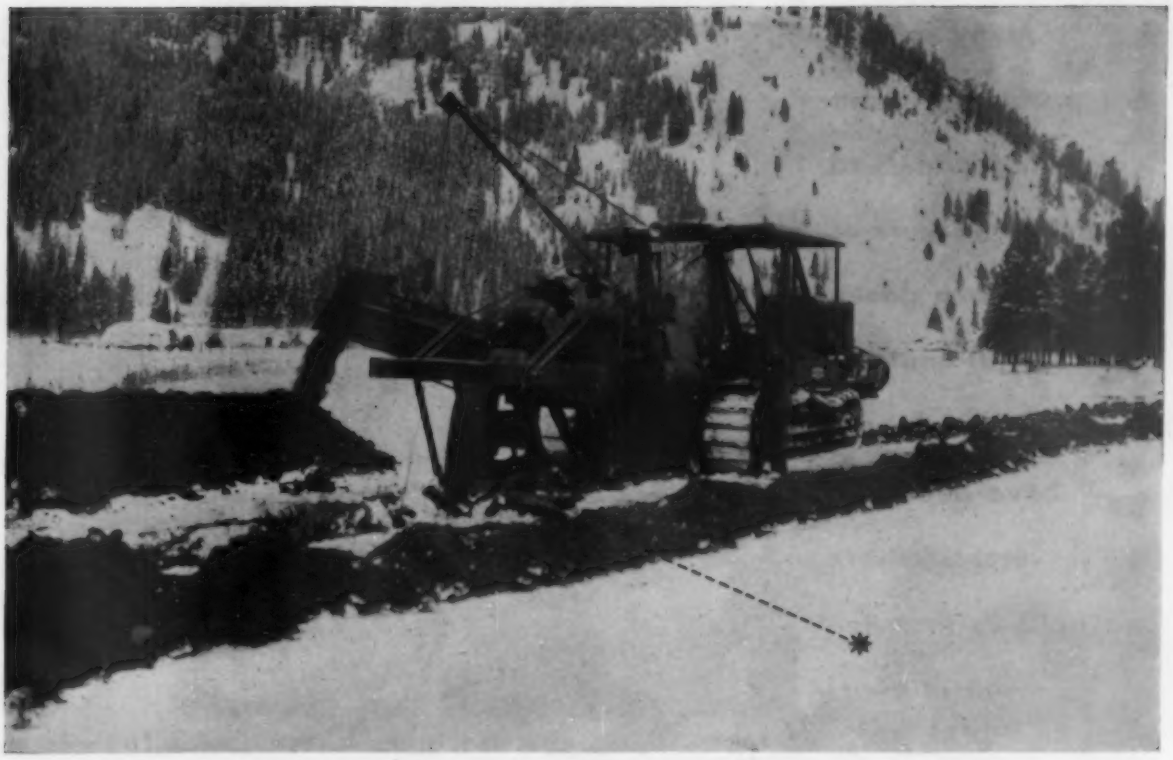

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CLEVELAND

Many unique problems—from watering camels to training workers of more than a dozen different nationalities in complex jobs—have been met successfully in Tapline's first five eventful years

Tapline control house at Sidon Terminal in Lebanon, western terminus of the Trans-Arabian pipe line system.

Camels drink their fill at concrete watering trough near the Badanah pump station along the Trans-Arabian pipe line system.

3) Providing water not only for the needs of the pump stations, but for local and transient populations and their livestock.

4) Providing medical and hospital care for a heterogenous work force, as well as for residents and travelers in isolated areas where medical services would not otherwise be available.

5) Providing housing and recreation facilities for employees and the families of key personnel in isolated desert outposts.

6) Tailoring its requirements for materials, equipment and food supplies to permit purchase of the greatest possible percentage in non-dollar currencies.

7) Conducting its affairs in a variety of currencies generated by sales of crude oil by off-taking companies in the world markets, together with the local currencies used in the countries traversed by the pipe line.

8) Training workers of more than a dozen different nationalities to work harmoniously together and to handle responsible and complex jobs.

9) Maintaining an efficient terminal with a high turnaround of tankers in an open roadstead at Sidon.

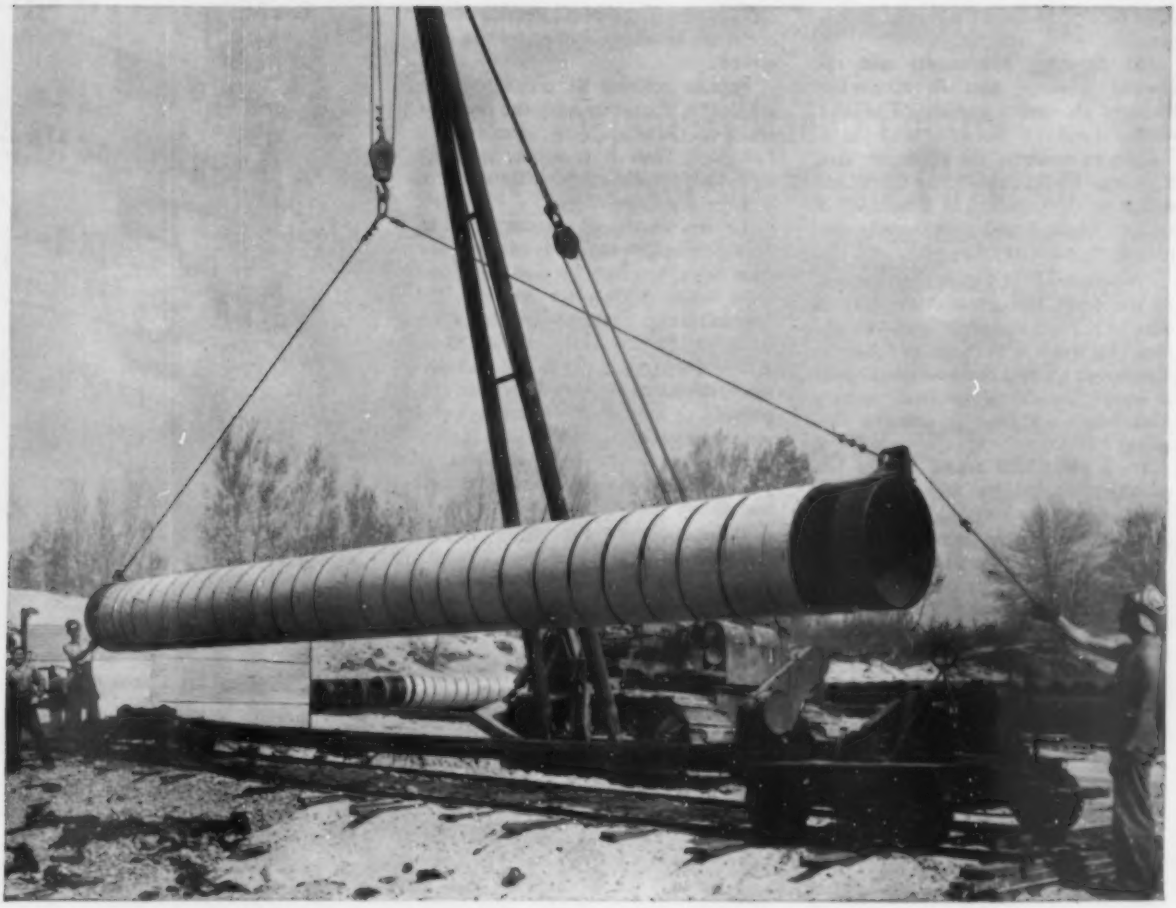
10) Coping with sharp and sudden changes in temperature with corresponding pressure fluctuations in the above-ground section of the line in Saudi Arabia.

11) Depending upon a high frequency system of radio communication, often in the face of chaotic interference conditions, as its only means of rapid communication between Sidon, four pump stations in Saudi Arabia, and a delivery point in Jordan, as well as company headquarters in Beirut and tankers offshore in the Mediterranean.

12) Maintaining constant liaison with representatives of four different governments on questions involving everything from customs and visa clearances to security and labor relations. Such matters become of first importance in an area where government laws and regulations have an unusually pronounced influence upon the day-to-day activities of a private business enterprise.

13) Maintaining sound personnel, wage and labor relations policies designed to follow a consistent pattern but at the same time to conform with the labor laws, sociological development and economic levels in four Middle Eastern countries.

14) Educating a relatively uninformed public on the whys and wherefores of operating a pipe line and what should and should not be expected



ANOTHER LINK IN A MILLION-MILE CHAIN

This 30-foot section of pipe has been coated, wrapped, and is ready for service. It will take its place in the vast underground pipeline network that moves a greater volume than do trucks, railroads, ships and planes, combined.

It will become part of a great subterranean system that is vital to America's everyday living.

Let the facts speak for themselves. The gas industry alone handles over 10,000,000,000,000 cubic feet daily through more than half a million miles of transmission and distribution pipelines. A 185,000-mile pipeline system moves liquid petroleum products across the continent. In addition, there are many thousands of separate pipeline systems used to transport steam for power and heating —and to deliver water through municipal piping.

But there are problems—and one of the most important of these is corrosion. Pipeline companies and utilities must protect their metal pipe against the many corrosive elements that exist underground.

That's where Dearborn comes in. Dearborn's complete line of NO-OX-ID Coatings and NO-OX-IDized Wrappers provide both chemical and mechanical protection against moisture penetration and soil action—protection that lasts for decades—under ground or under water. That's why leading pipeline companies and utilities everywhere look to Dearborn for long-term protection against corrosion leaks and deterioration.

We will gladly consult with your engineers on the best NO-OX-ID Coating and Wrapper Combination for your next pipeline job.

SPECIFY

Dearborn NO-OX-ID®

ON YOUR NEXT PIPELINE JOB

USE THE COUPON FOR MORE INFORMATION

Dearborn Chemical Company, Dept. PE
Merchandise Mart Plaza, Chicago 54, Ill.

☐ Please send details on NO-OX-ID Combinations.
☐ Have representative call.

Name.....*Title*.....

Company.....

Address.....

City.....*Zone*.....*State*.....

from the operation in the way of public benefits.

15) Assisting community and regional welfare and development through charitable contributions and technical aid.

Visitors entering the office of Vice President W. R. Chandler in Beirut are struck by the presence of a bottle of a smooth black liquid prominently displayed on his desk.

"It's crude oil," Chandler will explain to the perplexed guest. *"We keep it here to remind ourselves from time to time that we are still in the oil business. Sometimes we feel that transporting oil is merely incidental to other matters with which we have to concern ourselves."*

It's a point well made. Tapline has problems shared by few other pipe lines anywhere. Running it is a complex and difficult business.

Like its sister company, the Arabian American Oil Company (Aramco), from whose gathering system it receives its daily load of crude, Tapline's basic policy is one of enlightened self-interest.

That is to say, the company is convinced that its own best interests are served only if the best interests of the countries in which it operates are also served.

Tapline believes its progress is ineradicably bound up with the progress of Saudi Arabia, Syria, Jordan and Lebanon. Thus it is active in many fields that are not properly the concern of pipe lines elsewhere.

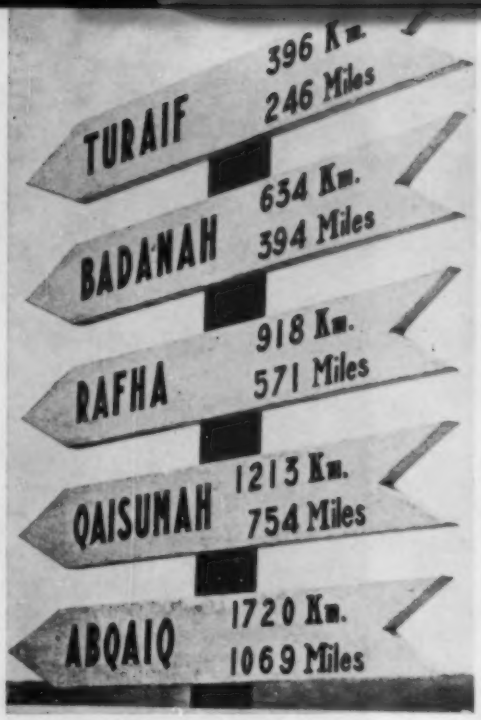
To the maximum extent possible, Tapline employs nationals of the countries through which its pipe line runs.

In Saudi Arabia, for instance, the overwhelming majority of the work force is Saudi Arab. These Saudi Arabs perform their duties side-by-side with the company's American employees, as well as with a smattering of nationals of other lands who are engaged as required to handle specialized jobs for which locally recruited personnel are not yet available.

In addition to Americans and Saudi Arabs, Tapline has on its payroll men from Lebanon, Syria, Jordan, Palestine, Bahrain, Qatar, Pakistan, Yemen, Aden, Somaliland, Holland, Norway, Italy and the British Isles.

Training Schools

At each of its pump stations and



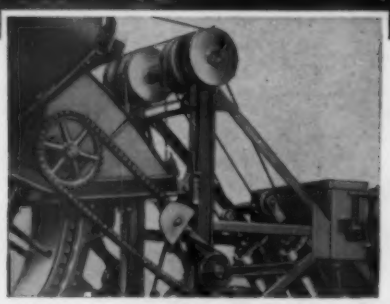
Direction sign post at Sidon Terminal, Lebanon, with distances to Trans-Arabian pipe line system pump stations.

Arab townsite at Badanah in Saudi Arabia.

NOW!

Instant Hydraulic Control of Conveyor Speed and Direction

Only Gar Wood Buckeye has it!



LIVE HYDRAULIC WHEEL HOIST, TOO!

Positions digging wheel faster, more accurately. Independent of all other operations. Operated from the seat by simple, one-hand controls.

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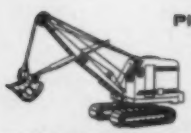
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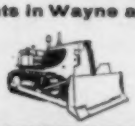
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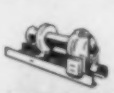
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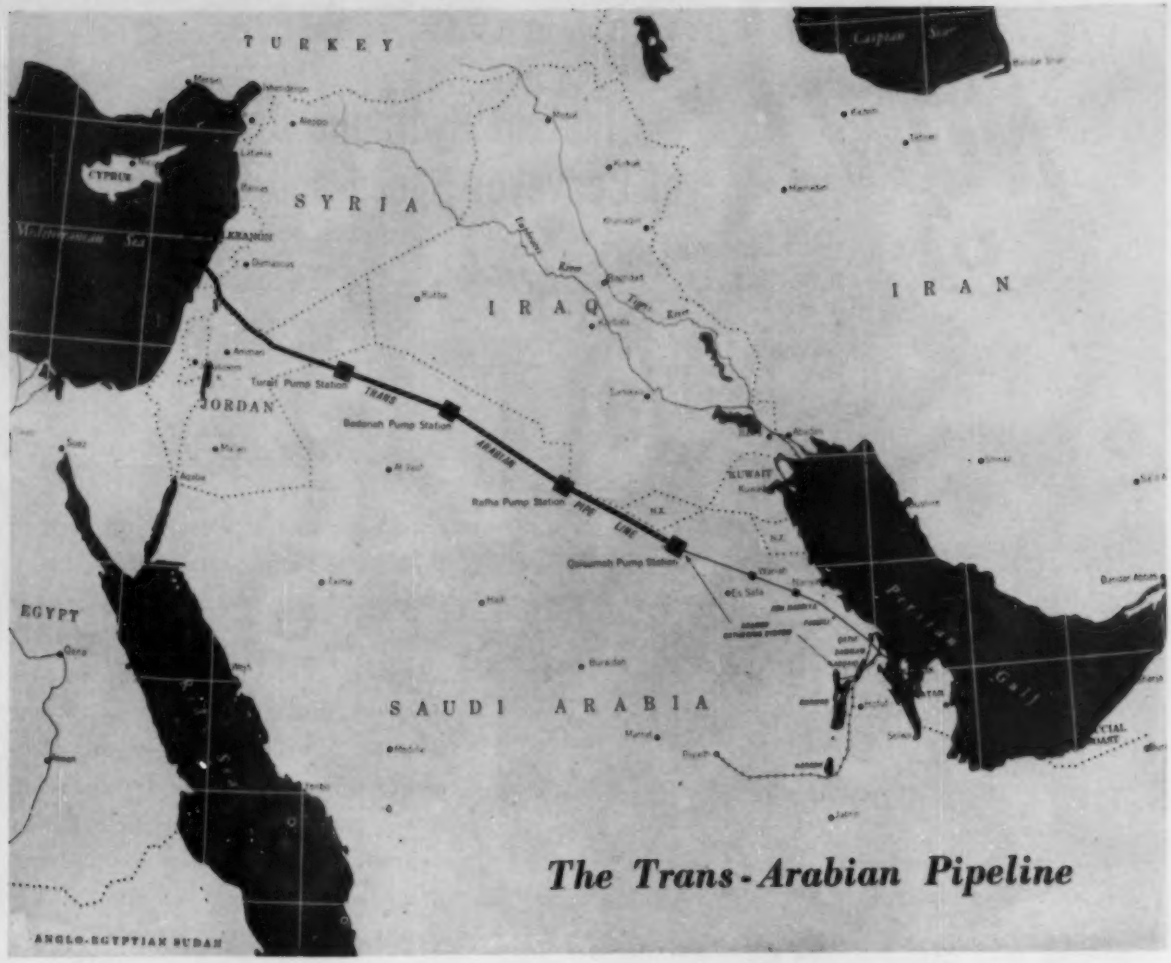

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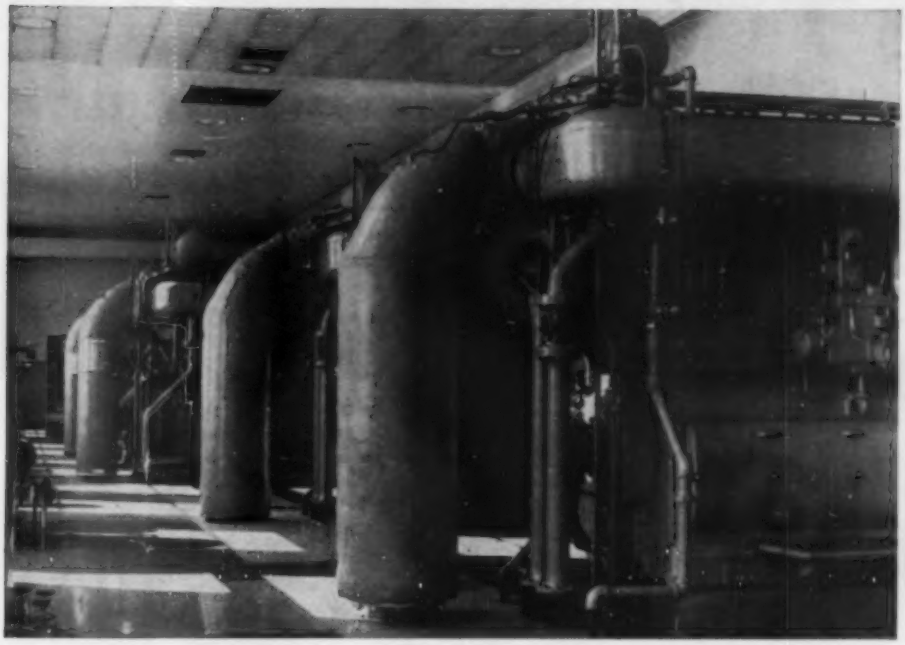

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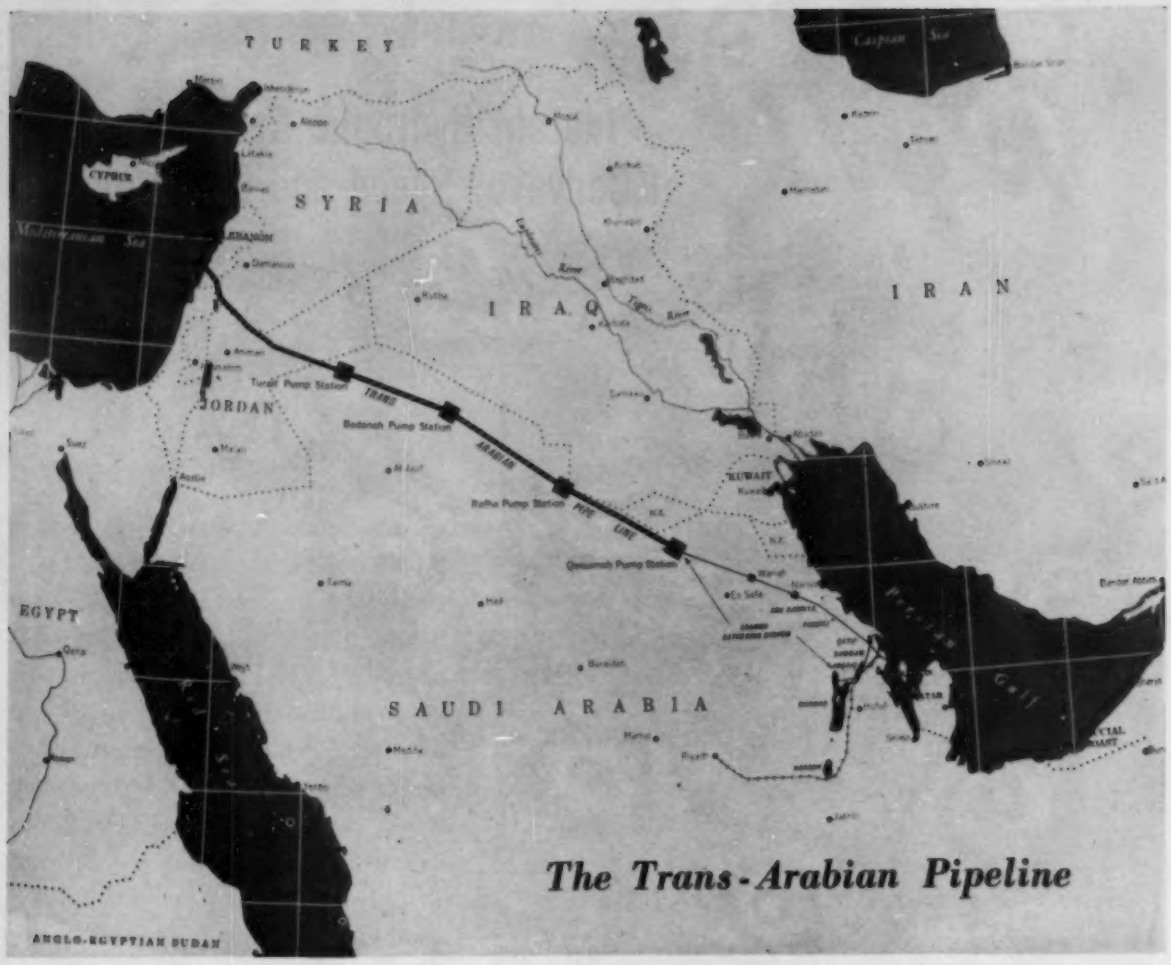

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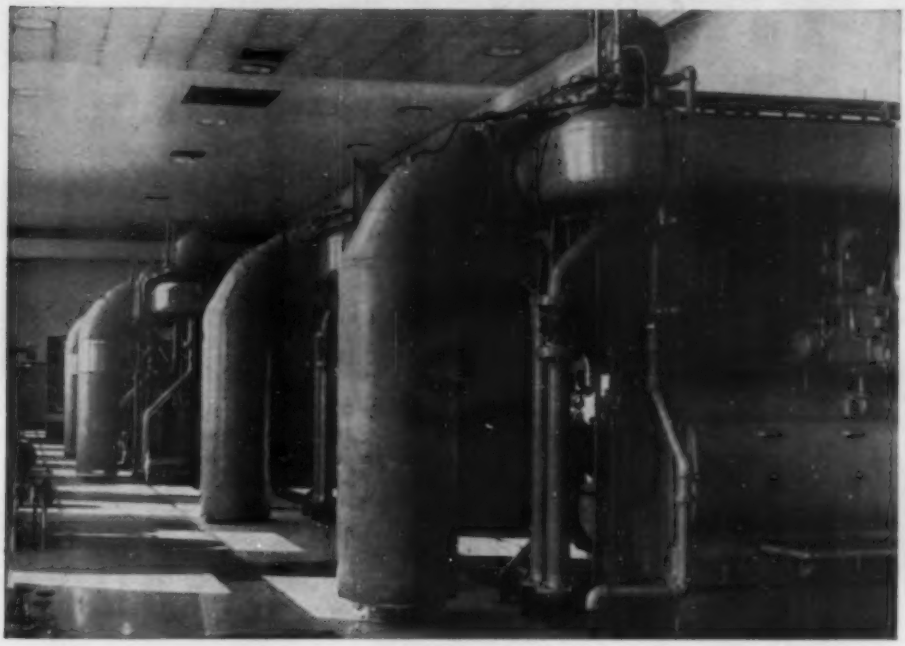

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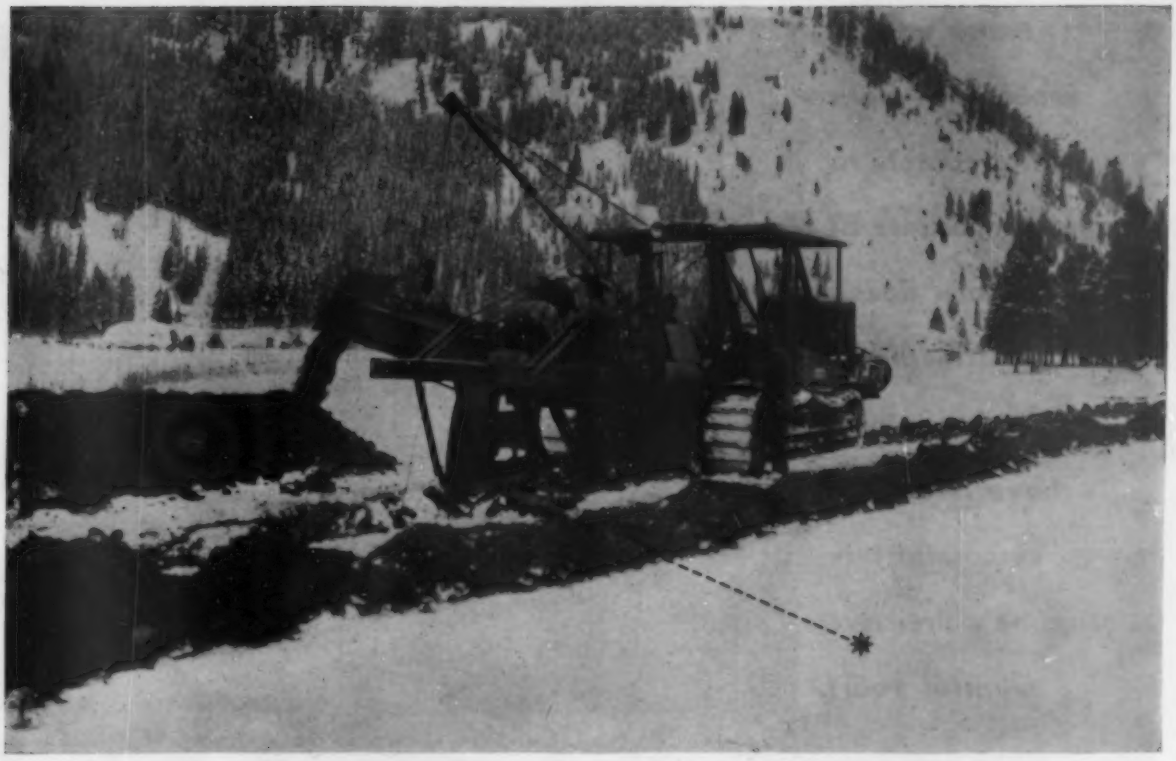

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CLEVELAND

Many unique problems—from watering camels to training workers of more than a dozen different nationalities in complex jobs—have been met successfully in Tapline's first five eventful years

Tapline control house at Sidon Terminal in Lebanon, western terminus of the Trans-Arabian pipe line system.

Camels drink their fill at concrete watering trough near the Badanah pump station along the Trans-Arabian pipe line system.

3) Providing water not only for the needs of the pump stations, but for local and transient populations and their livestock.

4) Providing medical and hospital care for a heterogenous work force, as well as for residents and travelers in isolated areas where medical services would not otherwise be available.

5) Providing housing and recreation facilities for employees and the families of key personnel in isolated desert outposts.

6) Tailoring its requirements for materials, equipment and food supplies to permit purchase of the greatest possible percentage in non-dollar currencies.

7) Conducting its affairs in a variety of currencies generated by sales of crude oil by off-taking companies in the world markets, together with the local currencies used in the countries traversed by the pipe line.

8) Training workers of more than a dozen different nationalities to work harmoniously together and to handle responsible and complex jobs.

9) Maintaining an efficient terminal with a high turnaround of tankers in an open roadstead at Sidon.

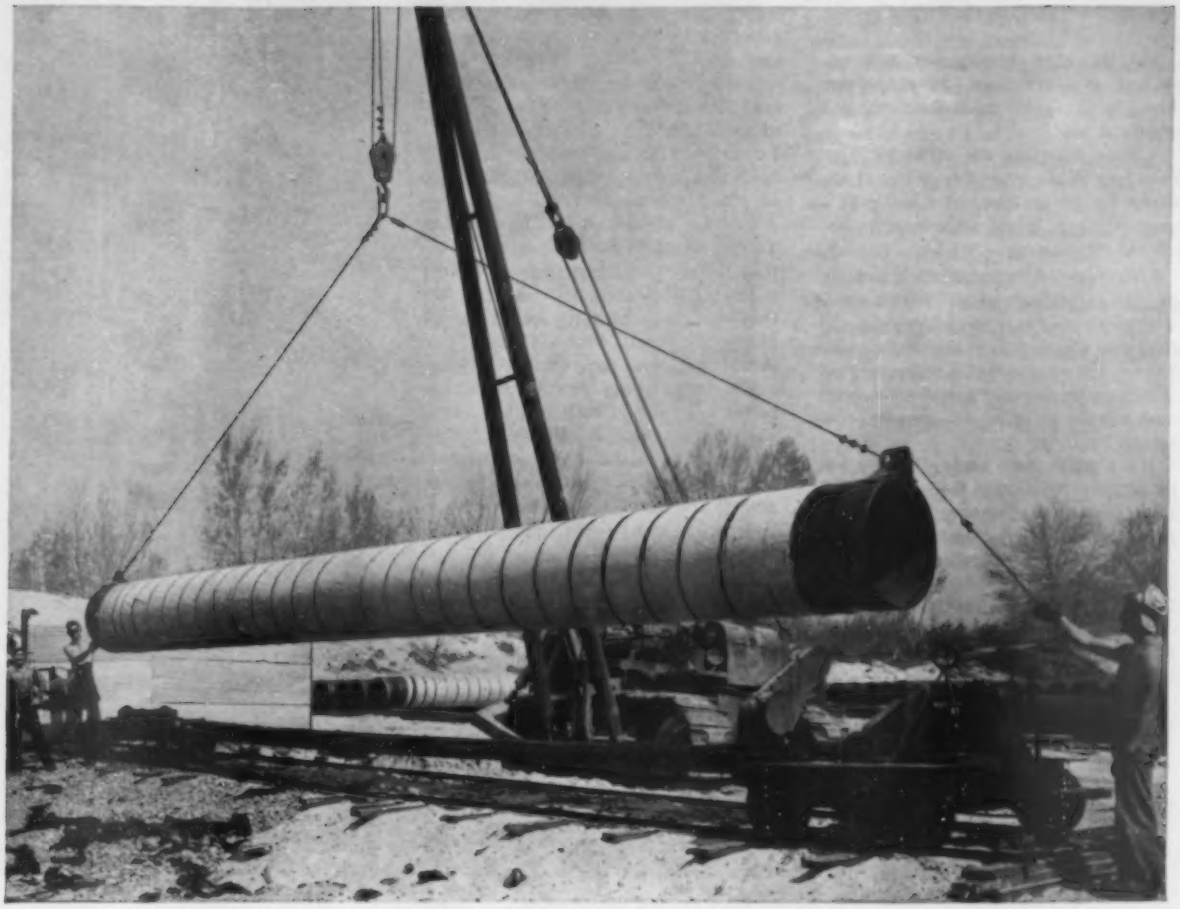
10) Coping with sharp and sudden changes in temperature with corresponding pressure fluctuations in the above-ground section of the line in Saudi Arabia.

11) Depending upon a high frequency system of radio communication, often in the face of chaotic interference conditions, as its only means of rapid communication between Sidon, four pump stations in Saudi Arabia, and a delivery point in Jordan, as well as company headquarters in Beirut and tankers offshore in the Mediterranean.

12) Maintaining constant liaison with representatives of four different governments on questions involving everything from customs and visa clearances to security and labor relations. Such matters become of first importance in an area where government laws and regulations have an unusually pronounced influence upon the day-to-day activities of a private business enterprise.

13) Maintaining sound personnel, wage and labor relations policies designed to follow a consistent pattern but at the same time to conform with the labor laws, sociological development and economic levels in four Middle Eastern countries.

14) Educating a relatively uninformed public on the whys and wherefores of operating a pipe line and what should and should not be expected



ANOTHER LINK IN A MILLION-MILE CHAIN

This 30-foot section of pipe has been coated, wrapped, and is ready for service. It will take its place in the vast underground pipeline network that moves a greater volume than do trucks, railroads, ships and planes, combined.

It will become part of a great subterranean system that is vital to America's everyday living.

Let the facts speak for themselves. The gas industry alone handles over 10,000,000,000,000 cubic feet daily through more than half a million miles of transmission and distribution pipelines. A 185,000-mile pipeline system moves liquid petroleum products across the continent. In addition, there are many thousands of separate pipeline systems used to transport steam for power and heating —and to deliver water through municipal piping.

But there are problems—and one of the most important of these is corrosion. Pipeline companies and utilities must protect their metal pipe against the many corrosive elements that exist underground.

That's where Dearborn comes in. Dearborn's complete line of NO-OX-ID Coatings and NO-OX-IDized Wrappers provide both chemical and mechanical protection against moisture penetration and soil action—protection that lasts for decades—under ground or under water. That's why leading pipeline companies and utilities everywhere look to Dearborn for long-term protection against corrosion leaks and deterioration.

We will gladly consult with your engineers on the best NO-OX-ID Coating and Wrapper Combination for your next pipeline job.

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Name.....*Title*.....

Company.....

Address.....

City.....*Zone*.....*State*.....

from the operation in the way of public benefits.

15) Assisting community and regional welfare and development through charitable contributions and technical aid.

Visitors entering the office of Vice President W. R. Chandler in Beirut are struck by the presence of a bottle of a smooth black liquid prominently displayed on his desk.

"It's crude oil," Chandler will explain to the perplexed guest. *"We keep it here to remind ourselves from time to time that we are still in the oil business. Sometimes we feel that transporting oil is merely incidental to other matters with which we have to concern ourselves."*

It's a point well made. Tapline has problems shared by few other pipe lines anywhere. Running it is a complex and difficult business.

Like its sister company, the Arabian American Oil Company (Aramco), from whose gathering system it receives its daily load of crude, Tapline's basic policy is one of enlightened self-interest.

That is to say, the company is convinced that its own best interests are served only if the best interests of the countries in which it operates are also served.

Tapline believes its progress is ineradicably bound up with the progress of Saudi Arabia, Syria, Jordan and Lebanon. Thus it is active in many fields that are not properly the concern of pipe lines elsewhere.

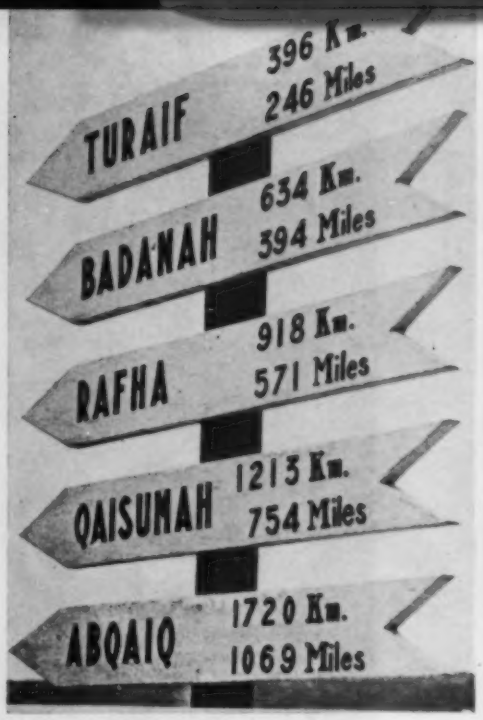
To the maximum extent possible, Tapline employs nationals of the countries through which its pipe line runs.

In Saudi Arabia, for instance, the overwhelming majority of the work force is Saudi Arab. These Saudi Arabs perform their duties side-by-side with the company's American employees, as well as with a smattering of nationals of other lands who are engaged as required to handle specialized jobs for which locally recruited personnel are not yet available.

In addition to Americans and Saudi Arabs, Tapline has on its payroll men from Lebanon, Syria, Jordan, Palestine, Bahrain, Qatar, Pakistan, Yemen, Aden, Somaliland, Holland, Norway, Italy and the British Isles.

Training Schools

At each of its pump stations and



Direction sign post at Sidon Terminal, Lebanon, with distances to Trans-Arabian pipe line system pump stations.

Arab townsite at Badanah in Saudi Arabia.

Mr. and Mrs. Charles Babb and their son, Charles, Jr., lunch in the dinette area of their home in the desert community of Badanah. Each of the Tapline pump station communities along the Trans-Arabian pipe line is a self-sufficient, complete little town, receiving mail and supplies regularly by plane and truck.

other points of operation, the company conducts training courses both in schools and on-the-job to equip its employees for more advanced positions.

Through a series of progress steps, employees are advanced in position and salary as rapidly as they master job requirements. Each man in a supervisory capacity is made to understand that regardless of his particular job part of this duty is to develop the latent skills and abilities of the national employees with whom he comes in contact.

This policy is paying off.

Except for an American operations foreman, one trainer and a head mechanic, the oil operations at some pump stations are now directed and carried out by locally recruited employees. Many locally recruited employees have reached the position of shift foreman, thus making it possible for pump stations to be manned entirely by non-American personnel at certain periods of the day.

Jordanians completely staff the delivery station and line maintenance camp at Qaryatain where approximately 7500 bbl of crude per month are turned over to the Jordan government. In Syria, only Syrians are employed. In Lebanon, skilled and trained nationals hold down the overwhelming majority of field and office positions.

At present, Tapline has only 120 Americans on its field payroll out of a total work force of more than 1200.

Tapline has proved that nationals of many countries and varying backgrounds can be welded into a harmonious and efficient work force. It takes pride in the fine record of continuous operations its employees have made possible over the past five years. Except when slowed by lack of crude at Qaisumah or a full terminal at Sidon, Tapline has maintained a line operating efficiency of 99.75 per cent.

And in five years the line has not experienced a single major break.

There Are Other Problems . . .

As pointed out earlier, it is in non-oil matters that Tapline encounters some of its most difficult problems.

In Saudi Arabia, Tapline has had to make water available where none was available before. As a result, thousands of bedouin and their flocks have made company pump stations their home bases. At Badanah, for example, a thriving community of more than 5000 population has grown up since the line was opened.

During the summer, the needs of the bedouin often sorely tax the capacity of the company's water systems. Last summer, at Turaif, western-most of the pump stations, more than 25,000 camels and uncounted thousands of sheep were dependent upon the company's water supply. This caused a serious shortage that was solved only when the local Saudi Arab Government authorities compelled a number of tribes to move to other areas.

During the exodus the company provided the travelers with water from tank trucks. Incidentally, when water is available, one camel will consume 50 gal of the precious liquid every three or four days.

A Private "Point Four" Program

In addition to providing water for people who live or camp near its pump stations, Tapline offers them technical services and other assistance in what has frequently been described as a "private Point Four" plan. This policy has led the company to plan and lay out townsites along the pipe line's path and to encourage private contractors and businessmen to undertake various public projects.

At present, some contractors are constructing homes for company em-

TABLE 1.

Location and elevation of Tapline's operating points.

	Miles	Elevation (feet)
Qaisumah, Saudi Arabia	0	1177
Rafha, Saudi Arabia	183.31	1455
Badanah, Saudi Arabia	359.79	1778
Turaif, Saudi Arabia	508.30	2719
Qaryatain, Jordan	610.83	2444
Sidon, Lebanon	754.10	254

ployees while other entrepreneurs are planning shortly to offer water, electricity, ice and other utilities to local populations.

Hospitals and Housing

At three of its pump stations — Qaisumah, Rafha, and Turaif — Tapline operates up-to-date infirmaries, while at Badanah it maintains a well-equipped central hospital. In addition, it operates clinics in Beirut and Sidon and has the use of some seven beds in the American University Hospital in Beirut. At present more than 12,000 clinic cases per month are handled along the pipe line in Saudi Arabia. Separate facilities for women patients are provided.

Employee housing is at all times a major concern of the company. At the pump stations, it provides and maintains bachelor living accommodations and quarters for families of key personnel, as well as housing for Saudi Arab Government personnel assigned to the pipe line project. It also operates air-conditioned community center buildings that contain cafeterias and recreation and library facilities.

A company plane landing at Badanah pump station. The Tapline communities along the Trans-Arabian pipe line system receive mail and supplies by regularly scheduled planes which fly "milk-runs" to the isolated pump station communities.

Much of Pipe Line Above Ground

The first of Tapline's pump stations in Saudi Arabia is at Qaisumah, where Saudi Arab Government oil royalty gagers are located, and where the line joins with the Aramco gathering system. Next is Rafha, close by the Iraq frontier, followed by Badanah and Turaif. (See Table 1.)

Of the 539 miles of pipe line in Saudi Arabia, 375 miles were constructed above ground, across the flat open desert, on concrete supports. This method of construction was used in areas where continuous hard rock was encountered only a few inches below the ground surface, and was found to be considerably less costly than buried line in solid rock ditch.

Most pipe lines previously constructed above ground in Saudi Arabia and elsewhere have contained expansion loops or bends to allow for expansion and contraction resulting from temperature changes. Tapline's above ground line was unique in that no such provision for expansion was made, the line having been laid perfectly straight with anchors only at changes in direction.

Thus fully restrained, there is no movement of the pipe with temperature change, with the result that the line is under either longitudinal compression or tension, depending on the temperature.

At the time the project was undertaken, there was considerable difference of opinion as to the wisdom of such construction. However, the experience of five years of continuous operation has indicated that the above ground method of construction used by Tapline is eminently practical, and highly satisfactory not only from the standpoint of initial cost, but also of maintenance.

The above ground line has the advantage of easy inspection and repair, and there is no corrosion to contend with. Maintenance costs of the above-ground line have been almost nil, in contrast to buried sections of line which are demanding increasingly heavy expenditures for corrosion protection.

Of course, such a long stretch of above-ground construction could have been undertaken only in a thinly inhabited and relatively flat, unbroken area. In Jordan, Syria and Lebanon, where the population is heavier, and where the terrain is rough and broken, it was considered more desirable to bury the entire line, almost all of which involved blasting of rock ditch.

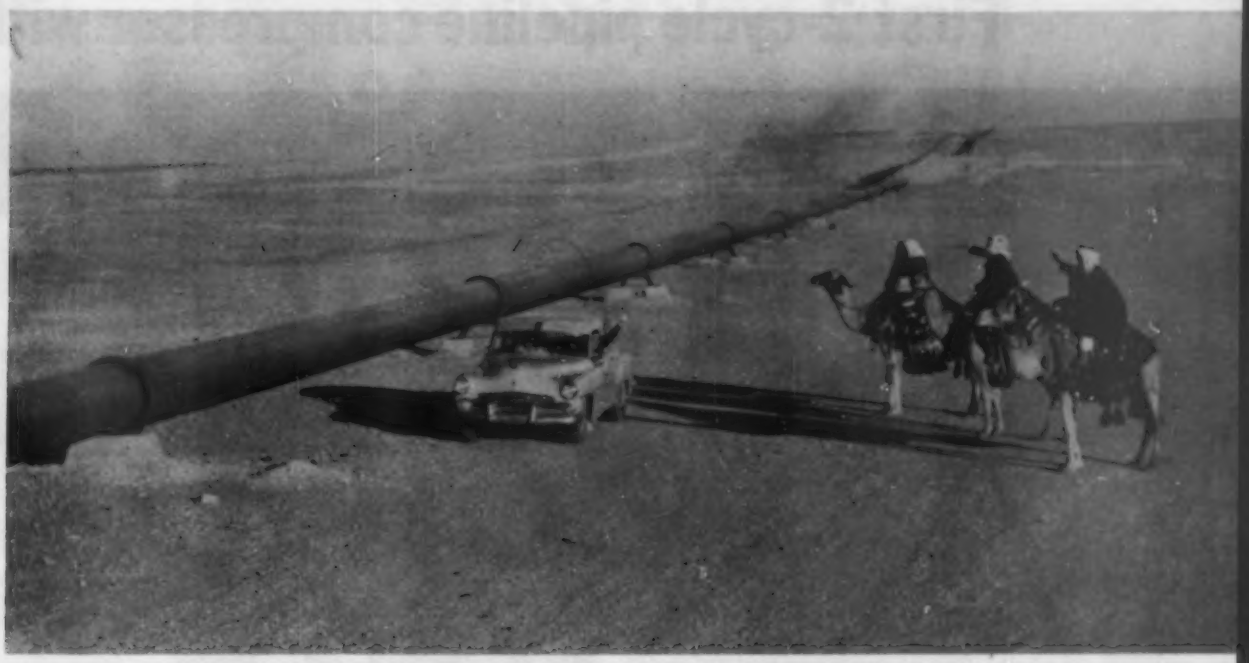
Large Temperature Fluctuations . . . .

The oil in the above-ground section of the line undergoes a daily temperature cycle change of 40 F in the summer and 20 F in the winter. Oil temperatures in winter reach a low of 35 deg and in summer a high of 145 deg. The temperature rise is rapid as the morning sun strikes the pipe. Resulting expansion of oil causes an increase in line pressure that arches the hydraulic gradient as much as 20 psi. As the oil cools at night the gradient is depressed.

Tapline was constructed of 30-in. pipe having wall thicknesses of 7/16, 3/8, 5/16 and 1/4-in. and of 31-in. pipe with 1/4-in. wall thicknesses. The pipe is distributed so that the heaviest walls are located where operating pressures are highest. Allowable operating pressure is set at 65 per cent of yield, thus lining up decreasing allowable pressure with decreasing wall thickness or increased diameter. As a result, permissable line pressure changes sharply at those points where pipe wall is reduced or large pipe diameter is used.

. . . Cause Operating Problems

During the first two years of operations station pressures were raised and lowered at carefully determined hours to allow for the arched gradient and thus to maintain line pressure at the controlling change or critical points at — but not over — the allowable. Subsequently, allowable pressure was increased to 68 per cent of yield, at the control points only, to permit constant pressures to be maintained at the pumping stations.



Arabs on camels greet Tapline party of pipe line checkers along the right-of-way of the Trans-Arabian pipe line system. About 40 per cent of the thousand-mile line is constructed above the ground.

Pressure Reducing System

The drop in elevation from Turaif to Sidon, three countries away, develops a shut-in pressure at Sidon of 960 psi. At full flow a back pressure of 450 psi is required to keep the pipe line packed or running full.

Maintenance of desired back pressure is accomplished through a pressure reducing system consisting of twelve 40-ft sections of 3-in. pipe inside which are welded a nest of seven 1-in. pipes.

In series with each of these "friction tubes" is a pressure reducing valve which takes a portion of the pressure drop. On nine of the tubes these valves are either closed or open wide. On the remaining three tubes, the valves will throttle to maintain desired back pressure as set on the control board.

During a major change in operation — such as from shut down to full flow, or full flow to shut down — pressure changes are made in a series of steps taken alternately at Turaif and Sidon. The magnitude of each step is always such that the line will be neither over-pressured nor slacked.

Control Centers

Throughout the system, all valves used during normal operations are opened and closed by electric motors controlled from a central board. At Sidon there are two control centers. One, in the tank farm, controls the incoming stream and routes it through the main manifold into one of seven leaders to the desired tank battery. Through this same manifold tanks assigned for the loading of tankers are lined up to desired submarine loading lines.

There are 20 tanks in the Sidon farm having a normal capacity of 188,000 bbl each and situated at elevations ranging from 280 to 370 ft. Tankers are loaded by gravity flow regulated by a second control center located on the shore. This center also handles, through a bunker manifold, the loading of either bunker fuel or diesel. These products, available to vessels lifting crude, were once brought in by tanker but since January, 1955 have been supplied by the Mediterranean Refining Company, located adjacent to the terminal from which it receives its crude.

Continuous Operation, Added Facilities

Some of the statistics of Tapline's operation are given in Table 2. The general increase in throughput to be noted is due in part to increasing demand, which has permitted more continuous capacity operation, and to added facilities. These latter include 200-hp booster pumps, installed on the incoming line at each station, which maintain a zero or less back pressure regardless of surge tank head, and additional tanks at Sidon to permit longer full rate operation when the

TABLE 2.
Tapline operating data.

	1951	1952	1953	1954	1955
Average bbl/day pipeline throughput	294,531	312,940	307,469	318,349	322,121
Average bbl/day lifted at Sidon	298,768	309,274	311,183	318,823	319,178*
Total number cargoes lifted	920	992	926	898	896
Average bbl per tanker	118,533	114,107	122,658	129,588	134,929
Average bbl per hour loading rate per berth	14,500	15,114	16,480	18,372	18,590
Most bbl/day lifted at Sidon	782,018	1,081,067	1,109,796	896,029	1,062,286
Hours port closed due to bad weather	500	605	836	696	412

*Includes deliveries to the Mediterranean Refining Company at Sidon.

First 2-cycle pipeline compressor with

Progressive engineering gives you more for your engine compressor dollar in the TURBO-UNIFLO

AFTERCOOLING FOR MAXIMUM LOAD CAPACITY. Air inlet manifold temperatures must be kept reasonably low to maintain wide engine operational range and overload capacity. This is important in high ambient temperature locations. Low cycle temperatures reduce maintenance on liners, heads, and pistons. Individual aftercoolers mounted immediately adjacent each cylinder inlet give maximum load capacity with accessibility.

MORE POWER FROM TURBO-UNIFLO DESIGN. Only cam-operated, timed exhaust valves permit early opening of exhaust to give complete evacuation of burnt gases, and controlled closing for trapping maximum supercharging air. Coupled with pulse-generator ignition, this quiet chain driven timing system gives top performance with minimum maintenance.

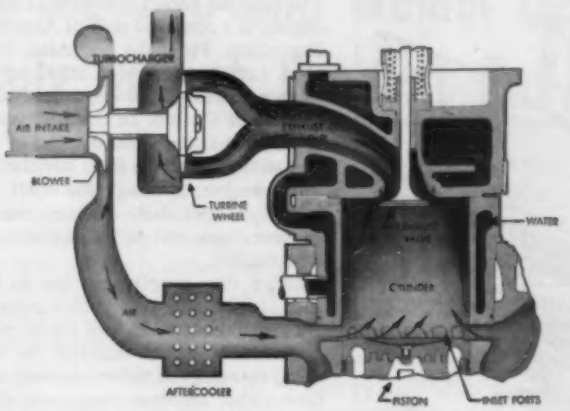
The only turbocharged 2-cycle engine-compressor with

exhaust-powered turbocharging at all loads

NO POWER-DRAINING EXTRA-DRIVE FOR SUPERCHARGING WITH THE "TURBO-UNIFLO"— WORTHINGTON'S SUTC GAS-ENGINE COMPRESSOR

In its first production year this unique two-cycle turbocharged gas-engine-compressor (750 to 2500 hp) has had remarkable acceptance. Designed for quiet exhaust powered pulse-type turbocharging, on the basis of Worthington's extensive two-cycle engine-compressor experience, more than twenty-four TURBO-UNIFLO SUTC's are either installed or on order. Built to lead the field for years to come, they're industry's best for gas pipeline applications.

By integrating exhaust powered turbocharging with field proven Worthington Uniflo scavenging design, Worthington engineers have developed a two-cycle engine-compressor unequalled for stability of performance over the *complete* range of speed and load requirements. Operating at relatively high compression ratio, the TURBO-UNIFLO has much smoother combustion characteristics than other engines with lower compression ratios. This is due to the basic timing arrangement, engine configuration, and design of exhaust manifolding. Sufficient exhaust gas energy is applied at the turbocharger, from engine start-up through all speeds and loads, to give full turbocharged effect without added external mechanical means for driving the supercharger. Low fuel and lube oil consumptions are other important results of this design arrangement.



TURBO-UNIFLO OPERATION — Exhaust valves are timed to open and generate a pressure pulse to move the turbine blades. This gives self-sustained starting and quick acceleration without external aid or mechanical drive. Blower delivers air under pressure to the aftercooler. Cooled air enters the cylinders through inlet ports 360° around the liner. During the scavenging period, the combustion chamber walls and valves are effectively cooled.

The Uniflo system is accepted as having highest scavenging efficiency. It also gives the best turbocharging-scavenge ratio due to complete absence of residual gases in the combustion chamber.

QUIETER OPERATION. Cast-iron exhaust manifolding—dry insulated, built-in air-pulse dampener, triple-strand silent camshaft chain, hydraulic valve lifters and elimination of any mechanically-driven air charging device assure quietness.

FEATHER VALVE. The feather valve is standard TURBO-UNIFLO equipment. It's the lightest, simplest and quietest valve—and operates with no impact!

For more details on the TURBO-UNIFLO, call your nearest Worthington District Office, or write Section E63, Worthington Corporation, Harrison, New Jersey. E-6.3

WORTHINGTON

exhaust-powered turbocharging from start-up through full-load

port of Sidon is closed by weather.

Sidon Terminal with its 3,500,000 bbl of storage capacity and five loading berths, is well capable of dispensing the capacity of the pipe line. The efficiency of the terminal operation is a source of pride to Tapline.

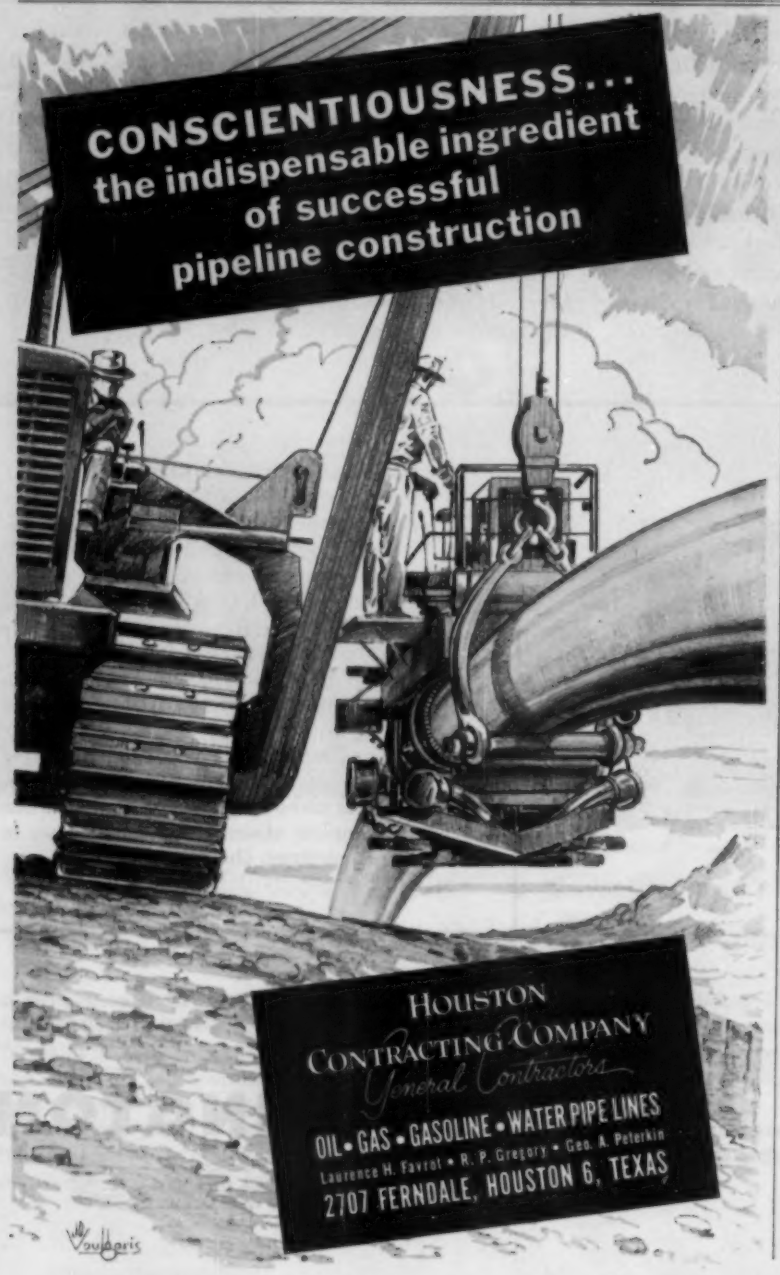
During normal conditions vessels which make regular calls and are familiar with terminal routine will depart fully loaded in from 10 to 15 hours after arrival, as indicated in Table 3. The longer average times for year around operation are due to the many vessels making only a single call, and to winter storms that may delay a number of vessels for several days.

Winter storms at Sidon can be both sudden and severe. They are characterized by rapidly shifting winds that on occasion have blown vessels out of the moorings in one direction while extra lines were being run for winds from the opposite quarter. Wire preventers have been installed to supplement ships lines during such periods.

Terminal Facilities

The five loading berths consist of 12 to 30-in. submarine lines terminating approximately one mile offshore and 2600 ft apart. Each berth has both a bunker and a cargo line. Bunker lines are 12, 14 or 18-in. in diameter and the cargo lines are 20, 24 or 30-in. Permanent moorings in all berths consist of five steel cylindrical buoys each fitted with a pelican hook, to which ships mooring lines are attached by Tapline mooring launches. These moorings will easily accommodate the largest tankers now afloat or building.

Vessels to be moored at Sidon are boarded by a Tapline Mooring Master about one mile from the moorings. He stays aboard the vessel until it is loaded and clear of the moorings on departure. Tapline has Mooring Masters of American, British, Dutch, Norwegian and Italian nationality. This leads to better understanding and cooperation with ship's officers of the many nationalities that call at the Terminal.



Operating Procedures

At the pump stations, line pressure is increased to a maximum of 920 psi through five single stage pumps operated in series. These are driven through 1 to 6.4 speed increasers by eight cylinder, 1710-hp diesel engines operating at speeds of from 325 to 360 rpm. To provide power for auxiliary equipment and the camp in general, three 1320-hp diesels drive 800-kw direct connected generators. Power demand is such that two units remain in operation continuously. As fuel, the engines use the 35 API gravity, stabilized sour crude, drawn from the line.

To put the line in operation, Tapline employed a complete staff of American dispatchers. From the beginning, however, Lebanese trainees acted as assistants and rapidly learned the fundamentals of the job. In the past year a Lebanese assistant chief dispatcher and four shift dispatchers have handled the complete job, although the chief dispatcher checks daily to keep current on operations and to be available for consultation.

Other than keeping the line in balance at maximum or required capacity, the dispatchers' main jobs are to maintain records and to schedule the flow of oil through the Sidon terminal tank farm. This requires long-range planning at times of high storage and bad weather when maximum rate must be maintained.

Radio Communications

The dispatchers and management maintain communication with the pump stations entirely by means of radio. The pump stations are connected by HF voice and teletype circuits to one another and to the Sidon Terminal. Oil dispatching circuits are connected from Sidon to Beirut headquarters via a VHF multichannel link. Administrative and general communication between the Beirut office and the Sidon Terminal is accomplished by dialing telephone circuits over the VHF

For hour after hour of sustained welding . . .

New G-E 200-amp Welder Delivers Steady Output Even at Full Load

Now, with the new G-E 200-amp engine-drive welder you can be sure of reliable construction welding—even for sustained operation. This powerful new welder makes it unnecessary to buy more expensive, higher rated machines just to make sure you get full 200-amp output when you need it.

This field-tested welder gives you steady output and 100% arc stability—hour after hour—even when operating at full load. This is made possible by combining a generator specially designed for field use with a direct-connected Hercules engine.

In addition, the high recovery voltage of the welder gives you complete freedom from "popouts," no matter what type or size electrode you use or where you set the controls.

This rugged new G-E welder has already received the enthusiastic approval of pipeline and construction weldors, foremen, and superintendents. Test it yourself and take advantage of its many advanced design features . . . new engine slow-down control to save fuel and oil while not welding; heavy gauge metal construction (16-gauge canopy, ¼-inch crossbars) to withstand rough field conditions; nonprojecting generator protected by full length canopy; and many others.

Contact your nearby G-E Welding Distributor (he's listed in the yellow pages of your phone book) or write for bulletin GEC-1333, Section 714-4, General Electric Co., Schenectady 5, New York.

Progress Is Our Most Important Product

GENERAL ELECTRIC

FIELD-TESTED DESIGN of new G-E 200-amp welder solves old and costly load drop-off problem in construction welding.

OSCILLOSCOPE shows 200-amp welder delivers steady output, full heat at full load.

EXCLUSIVE ELECTRODE SELECTOR, CURRENT DIAL—Dual controls make current control easier and more accurate, eliminate guesswork in setting and resetting.

radio link. Calls between pump stations and the Beirut office are connected by a radio operator at Sidon.

Twenty-four hour operation of oil dispatching circuits is difficult at times because of the vagaries of HF transmission and complex interference conditions. The system as originally installed utilized centrally-located automatic HF relay transmitters for the oil dispatching circuits.

Due to interference conditions this had to be abandoned and the circuits were brought directly into a continuously-manned location at the Sidon terminal. Thus the operating technician on duty can make necessary adjustments as conditions change.

In the vital matter of transport, the company operates, in conjunction with Aramco, a fleet of DC-3 airplanes. These sturdy craft make on an average of three round-trip flights a week to the various pump stations, where first-class landing strips are maintained. The DC-3's serving the pump stations and other operating points are flown on an average of 200 hours every month. During an average month approximately 130 passengers are transported by air between the pump stations and Beirut. A similar passenger load is carried between the pump stations and Aramco's headquarters in Dhahran, Saudi Arabia.

Approximately 45,000 lb of cargo are carried by company aircraft to the pump stations each month. This cargo consists in the main of food supplies, household and personal effects of employees, spare parts and such emergency items as are required from the company's warehouse in Beirut.

Management Operations

While Tapline is an American corporation, it maintains its headquarters in Beirut, Lebanon, in order to exercise more effective control over pipe line operations, and to keep in closer touch with the all-important three "R" 's of any large overseas operation: **Government relations, public relations, and industrial relations.**

A small office is also maintained in New York to handle liaison with shareholder companies, recruiting and processing of American employees, coordination of oil movements, some phases of advanced engineering and planning, and coordination of procurement of materials which must be purchased in the United States.

Yes, running a pipe line in the Middle East is a complex task. In coping with its varied oil and non-oil problems, Tapline's management keeps one thought uppermost in mind: The pipe line must be kept competitive with tankers, especially those new super vessels coming off the ways in steadily increasing numbers. If it does not meet the competition of tankers it will not justify its existence. That is the Tapline story five years after..... ★ ★ ★

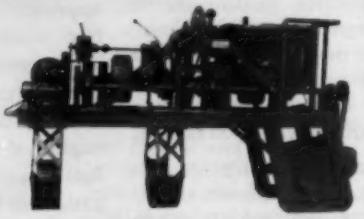
TABLE 3.
Tanker loading data.

	Examples of typical loadings—normal conditions		Average of all tankers
	T-2	Super	
Date loaded	9/10/55	9/2/55	1955
Bbl loaded	119,786	201,597	134,929
Loading rate—barrels per hour	21,899	23,914	18,590
Hours in moorings	8:33	12:15	12:23
Hours in port	9:36	13:15	20:18

CROSE *Auger Type*

ROAD BORING MACHINE

for installing casing up to and including 42" in Diameter . . .



FASTEST, SIMPLEST, MOST ECONOMICAL METHOD OF BORING CROSSINGS WHERE ROCK IS NOT ENCOUNTERED.

Casing is installed as boring progresses — eliminates cave-ins, prevents settling of concrete slab highways or railroad beds. Extremely accurate in alignment. Also available in smaller lightweight model for handling casing up to 12" diameter. Send for Bulletin.

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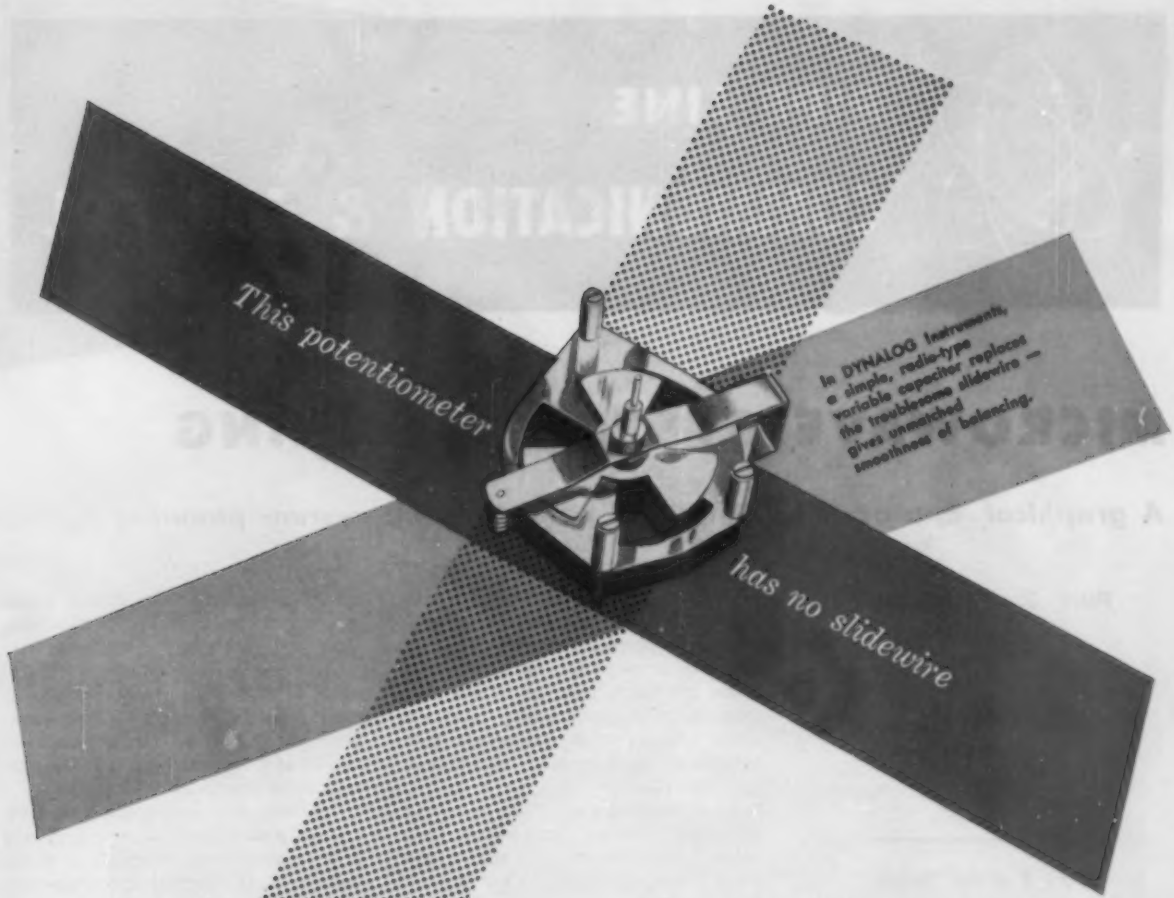
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MICROWAVE SYSTEM PLANNING

A graphical approach to simplified point-to-point system planning

Part 3: Microwave Site Selection

Lee Elmore
Collins Radio Company
Dallas, Texas

About Part 3 of the Series:

The choice of microwave station sites is one of the more permanent and important decisions in microwave system planning. This article outlines the practical considerations in site selection and system routine in terms of the effect on equipment provisions, cost factors, and overall system reliability.

When site selections are finalized and options are obtained, it is advisible to file license applications with the FCC well in advance of contracting a system. The license can then be processed concurrent with the bidding and contract negotiations, so that the supplier can begin construction of towers and buildings on the site without waiting for construction permits. The writer is acquainted with two recent systems in which the contractor was delayed considerably by lack of CP's. In one case, a system planned in northern latitudes was delayed into the winter months so that construction had to be postponed until spring, thereby delaying provision of the needed communication facilities.

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MICROWAVE SITE SELECTION AND PROPAGATION path layout are important and interdependent factors in planning a point-to-point communication system. Choice of station sites fixes the propagation paths and has a major bearing on overall system cost, equipment requirements, and ultimate performance.

Tentative sites can be selected from a "paper" survey (employing topo maps, profile charts, and the Microwave Planning Graphs in this series). Such tentative sites and alternate choices provide the starting point for a microwave field survey. The field survey is required to verify propagation paths, confirm site selection, determine exact tower heights, and plan the radio equipment installation. The microwave survey techniques were covered in Part 2.

Geography is a major factor in selecting microwave sites and paths, because the prime requisite is a clear line-of-sight path between towertops of adjacent stations. Part 1 of this series showed how to use a profile chart and Fresnel zone graph to plan a simple line-of-sight link.

The practical considerations involved in site selections are outlined in the following paragraphs for reference in system planning.

The propagation factors that must be considered over the paths between the sites for various terrain types and various atmospheric conditions will be covered in Part 4 of this series and graphically summarized in a dual Path Planning Graph, which relates earth size, beam bending, Fresnel zone clearance, and transmission values for both over-land and over-water paths.

The path length between sites is limited by equipment factors (dish size, transmitter-receiver equipment gain, reflector or coax loss in high towers, etc.) and performance factors (fade margin down to a specified voice channel S/N ratio, propagation, reliability, etc.). These equipment and performance factors will be fully covered and graphically depicted in subsequent articles of this series.

The longest or worst path is the controlling path insofar as overall system performance under normal or faded conditions. In selecting sites, therefore, keep the path lengths moderate and in the same magnitude; avoid a number of short hops in series with one long hop.

Microwave stations are usually limited to an average separation of 30 miles or maximum of 40 miles by practical tower heights and conservative fade margins. The actual spacing must be determined by a microwave survey and consideration of the above propagation, equipment, and performance factors.

Site Selection

Microwave sites fall into two categories: (a) The locations that require communication, and (b) the intermediate relays that link the communication points into a continuous network.

a. Communication points become the terminals and drop repeater stations of a microwave system. These sites are generally on company premises at pumping stations, pipe line terminals, office buildings, refineries, or similar operating locations that require communication channels for dispatching, supervisory control, telemetering, telephone, teletype, VHF base operation, centralized office accounting, facsimile or data transmission.

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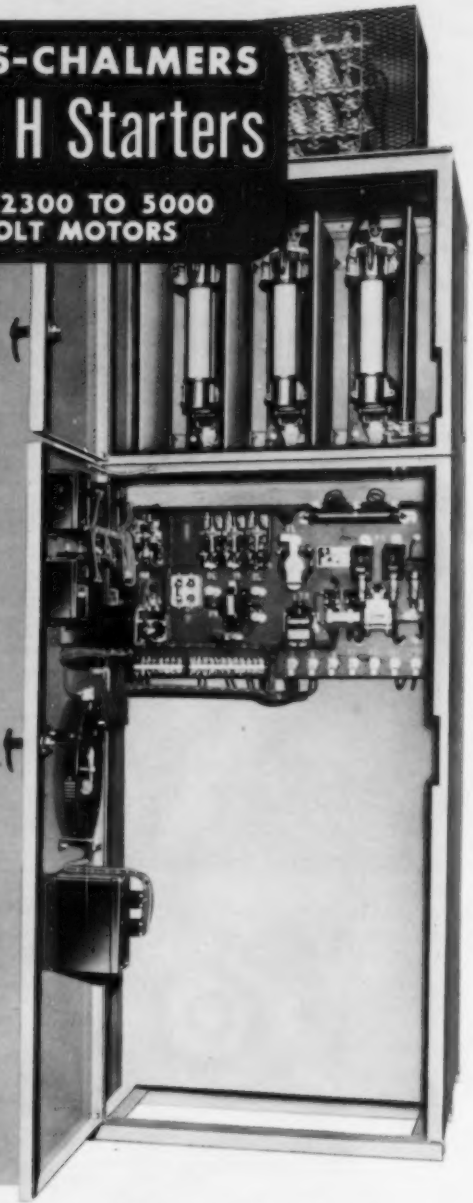

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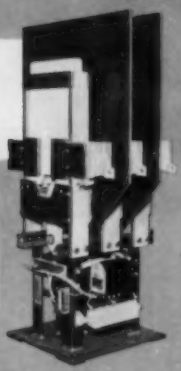

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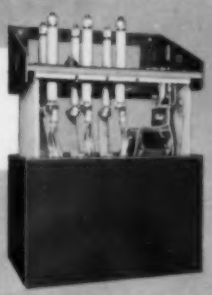

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the overall routing and extent of a microwave system. These sites are fixed by the present and anticipated requirements for communication. The exact location of a microwave station on such premises is a matter of practical installation. At a pumping station, for example, ample area for tower guying may be the most decisive factor. At a downtown office building, the available location for installing antenna, RF or channeling equipment usually dictates the exact site.

b. Relay sites are necessary for linking communication points when a line-of-sight path cannot be established otherwise. Microwave relays are spaced so as to maintain proper path clearance and signal levels. A microwave relay station receives and re-transmits radio signals at the original level, thereby compensating for space loss or attenuation of the radio signal that occurs in transmission.

The logarithmic addition of receiver noise in db at tandem microwave relays causes a slight reduction in overall system RF carrier-to-noise ratio in a multi-hop system, as will be shown in a later graph.

Station Types and Routing

The routing of a microwave network to link the communication points via intermediate relays can often be laid out with various trunk and spur arrangements. The RF equipment provisions and standby protection often differ considerably at major terminals, drop repeater, through relay, junction stations, and spur terminals. The basic routing schemes are summarized below with pertinent comments.

Tandem. When the communication points are strung out in a long line, such as along a pipe line route, the microwave system usually consists of two terminals and a number of intermediate relays in series. Relays located at communication points are called drop repeaters. Relays that do not provide any communication (other than a service channel and fault alarms) are called through relays. The only difference is the provision of multiplex at drop repeaters.

When all stations are in series, standby RF equipment should be uniformly provided. Standby power provision may vary with the degree of local power reliability. City locations or refineries that have good backup may not need standby power sources. Rural sites where the power fluctuates widely or fails frequently may necessitate a battery bank or flywheel generator to isolate the station from these outage causes, because in a tandem route the weakest link determines the strength or continuity of the chain.

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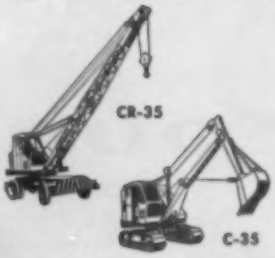

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tion is always provided at drop relay stations to isolate any faulted or faded sections so that communication is maintained over the remainder of the system.

When all stations in series are provided with full RF standby with rapid switchover and continuous power is assured, the continuity of through communication will be nearly 100 per cent. When a fault occurs, the station switches to standby operation and notifies the maintenance station of the nature of failure so that the technician can correct the fault and restore "main" operation. All this occurs without a break in through communication.

The only fault that should disrupt through communication would be a deep propagation fade. Incorporation of a fade margin of 30 db will assure usable voice circuit quality as long as 1/1000 of the normal signal is received. Selection of paths to avoid excessive fades is covered in Part 4, and subsequent parts will treat fade margins and the statistics of propagation reliability.

If a small tandem system involving several through relays in series is installed initially without standby RF for economy reasons, special provision should be made at the relay sites for partial sensing and a continuous no-fault tone to permit the maintenance man to determine which station to visit in case of complete station outage.

Trunk and Spur. Often there are stations off the main route that require communication. The route can be zigzagged to include these sites in series as above, but a preferable method is to provide stubs off the main trunk route. Such spur stations may be afforded full standby protection or none, depending upon the need for continuity of communication to the spur stations.

Spur sections may consist of a terminal only or may include several intermediate relays.

The trunk line station that branches off to the spur is called a junction station and may or may not provide drop channels. It is generally desirable to locate junction stations at major drop points, as this arrangement lumps much of the equipment in a system at one site that is logically a good maintenance headquarters.

As junction stations provide RF links in three or more different directions, the path bearings and antenna system should be planned so as to avoid physical conflict in mounting dishes or reflectors on the tower.

Hub. When a number of stations in an area are to be linked, one centrally located station at a headquarters or control point may be used as a hub, with RF links eminating like spokes of a wheel out to the other sites. This routing is fine for a few legs, but if a number of different path directions becomes excessive, serious problems arise in antenna mounting, available frequencies, and interfering lobe patterns. Such problems are minimized by using vertically mounted dishes instead of reflectors and by employing higher frequency bands to keep beamwidths narrow and sidelobes at a minimum.

Round Robin. It is sometimes possible to route a system around a number of stations in an area or via two converging legs so as to form a complete loop. Such a round robin system will provide a highly reliable system even without standby RF. Bridging the channeling equipment across the RF in both directions at all relays provides alternate routes to a back-to-work terminal station. Failure of one of the round robin relay stations or a propagation outage in any one link will not keep the adjoining stations from getting through to the round-robin terminal.

Overshoot and Interference

In selecting routes or frequencies for multi-hop systems, the possibility of overshoot should be considered. Overshoot occurs when the beam transmitted from a station is abnormally propagated so that it is received several stations down the line, thus interferring with the normal signals. This can oc-

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FIG. 1. Tall and sturdy, this 360-ft tower at Oklahoma City drop repeater site in Sinclair-Continental system is highest microwave tower erected to 0.5° rigidity. Two 8-ft by 12-ft reflectors and VHF antenna are mounted at top. Triangular tower has 4-ft facing and is guyed at 5 levels by 6 anchors.

cur only if the frequency and orientation of the antennas coincide.

The beamwidth and bearings of all dishes operating on the same or close frequencies should be checked to avoid interference under overshoot conditions. Sites should be selected to avoid in-line paths at multiples of the frequency assignment pattern. Four-frequency RF systems are safer than 2-frequency RF systems that repeat the allocation plan every two sites. The narrow beamwidths at higher bands provide effective isolation and permit more nearly in-line routing of systems.

Site Considerations

Access roads and primary power. Sites for microwave stations should be selected for convenient year-around access and available primary power. Road building and power line erection are both costly, and it is often more economical to provide higher towers or intermediate relays rather than build stations on mountain peaks or other locations that have no roads or power available. The reliability of the power source (especially in the case of long rural service lines) and the winter condition of the access roads should be considered.

In considering the economics of a site that requires some access road building or power pulling, the best sources of cost estimates are the power company and local contractors. If the site is adjacent to a public road, the only roadway required is light grading and graveling on the site.

The cost of providing primary power to the site depends upon the availability of nearby low-voltage service, the possible requirement of step-down transformers, the station power demand and use factors, and the length of power line to be run from the source to the service pole or weatherhead.

The routing and condition of public roads that will be used in traveling between adjacent sites should be considered, as the time and mileage required for a maintenance man to make the trip will have a direct bearing on rapid correction of faults and on cost of maintenance. Travel time and expenses are a large factor in operating cost. The number of stations that one technician can service is limited by mileage as well as by number of sta-

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FIG. 2. Back-to-back dishes used at passive repeater site; 8-ft dishes bend the microwave beam 96° to avoid obstructing hill between two "active" stations.

tions. One man can usually handle no more than 5 or 7 stations, 150 to 180 system route-miles, or approximately 200 to 250 interconnecting road-miles.

Power service required is usually single phase 230/115 volt. The station load depends upon the type and amount of radio equipment, dish heaters, tower lighting, efficiency of power units (rectifier power supplies, flywheel generators, or battery chargers), fans, space heaters, overhead lights, and reserve for equipment expansion and test apparatus.

The station load may be kept low by using equipment with fewer tubes and low-power transmitters, use of efficient mag-amp power supplies, installation of photo-cell controlled tower lights, and provision of a good snow detector to minimize dish heating.

Station power requirement varies from 750 watts normal and 2500 watts maximum at a typical non-standby terminal station to 5 kw normal and 20 kw maximum at a major drop repeater station.

In battery operated stations, some economy and better performance of chargers can be effected if three-phase power is readily available. The ripple frequency of 360 cycles is more readily filtered. This may be taken advantage of at most pump stations, but remote relays have to be satisfied with single phase.

The power line fluctuations and outages should be considered, especially on the end of long rural lines. Fluctuations in frequency on the power line or output of a standby engine generator pose problems for any equipment that uses frequency-sensitive line regulators. Variation of line frequency will not affect mag-amp regulators.

Voltage fluctuations and the outage history should be checked if possible. Frequent short interruptions of power service or wide variations in voltage may cause deterioration or malfunction of standby engines or transfer panels under such intermittent start-up-and-off service.

Tower and Soil Factors. In relatively flat country, the distance between stations is limited by practical and economical tower heights. Maximum tower height is limited by dollars, db's, and site factors.

Tower costs are dependent upon type of construction, available site area, rigidity or twist specification, lighting requirements, ladder provisions, and type of soil. Guyed towers suitable for microwave cost approximately $20 per ft of height up to approximately 300 ft. The cost of tower steel and erection begins to soar beyond 350 to 400 ft.

In very soft soil (bearing 500 to 1200 lb per sq ft as contrasted with normal 3000-lb soil), this cost may be more than doubled by the customary requirement for deep pilings and massive anchors. The use of deep pilings for a guyed tower base may be eliminated by a well-engineered pad using reinforced or prestressed concrete to spread the tower load over a large area.

In selecting sites, the area required for guying should be considered. The length of each guy leg is usually 0.8 of tower height on level ground. A 300-ft triangular tower thus requires three guy anchors 240 ft from the base and 120 deg apart. A 300-ft square tower requires four anchors located at the corners of a 340-ft square, with a border for working area. Dual towers or H-frames require approximately the same dimensions as a square tower.

The plot should always be large enough to permit orientation of guy directions with respect to path directions so as to minimize the loading effect of tower-top reflectors or dishes. Planar towers, which require guying in only one major axis, are available for narrow sites such as ridges, road-side strips, or limited property area.

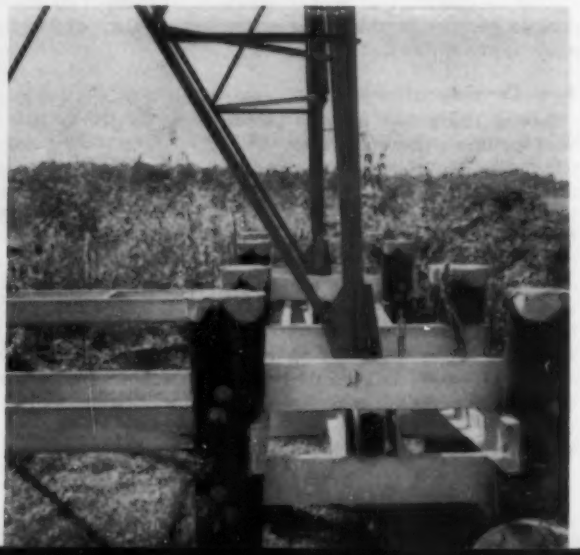
Sites that have insufficient area for guyed towers require self-supporting towers, which are quite costly and limited in height. The cost may be justified by the high price of real estate in city areas or in bayou country where dry land is scarce. Microwave twist specifications and cost limit self-supporting towers to a practical height of 120 to 200 ft.

Rocky sites may require boulder removal, blasting, air hammer work or drilling of tower anchors and bases. Rock anchors may sometimes be utilized if the rock strata are continuous. The use of a rotary drill will provide excellent anchors without blasting in sandstone or other relatively soft rock. Such a rig can also be used advantageously at sites with normal soil to provide almost ideal anchors in undisturbed earth.

Relatively flat sites are preferable. Differences in elevation between base and anchors of 0.1 to 0.2 tower height

FIG. 3. Float-charged battery banks isolate microwave system from wide fluctuations or frequent outages of power service at remote sites.

FIG. 4. Typical foundation for 120-ft self-supporting microwave tower in marshy soil. Four deep pilings per leg cause foundation cost to equal tower cost.



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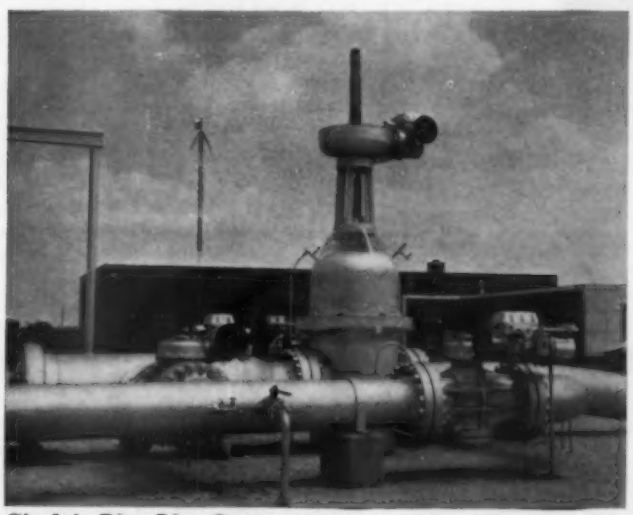
Public Service Company of Indiana, Inc.

Microwave radio aids in controlling supply of electricity for the state of Indiana. Four branches of a G-E Microwave system—combining voice and telemetering channels—originate at utility headquarters in Plainfield. From this hub regional demands are controlled according to local needs. Load control information obtained by remote control telemetering is analyzed, then transmitted to generating stations in necessary areas. Entire electrical power system is linked solidly by microwave radio.

Busy Tower

Antenna receives, transmits, or relays voice or telemetering signals. Antennas like these link headquarters with generating plants and sub-stations over a wide area.

P.S.I.'s microwave network provides utmost dependability because of standby equipment, fail safe feature, and because equipment can be concentrated at specific locations where it can be fully protected and easily maintained.



Sinclair Pipe Line Company

Microwave radio helps Sinclair coordinate flow of crude oil and oil products over many states—even turns pumps on and off. 7 voice, 4 telemetering channels link Cushing, Oklahoma and East Chicago, Indiana. Another channel permits remote control of 16 VHF radio base stations along the line which provide communication between over 100 radio-equipped vehicles and any company office in the microwave system. System is capable of providing up to 12 additional channels as needed.

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are readily compensated by longer guys, but severe slopes require careful analysis.

The above tower factors should be considered in site selection. Later in the series we will cover the db aspects of tower height (coax loss at lower bands, reflector gain at 6700 mc, rigidity and twist specifications, beamwidths, lobe patterns, wind and ice loading, multidish or reflector mounts, lighting requirements, and other system planning considerations).

Airports and Airways. The location of sites near airports or along the airways may limit the permissible tower heights and affect tower lighting requirements. An estimate of such may be obtained from local CAA authorities, but the requirements cannot be assured until the FCC license is granted.

Tower heights, permissible lights and lighting requirements stated in the construction permit sometimes vary from the license application because of final CAA or air association objections based on flight hazard. Selection of sites more than 10 miles distance from all airports and airways will avoid any objections and may permit economizing on the initial and operating cost of lights.

Antenna apparatus can be mounted on top of existing buildings without hazard to aviation if the structure projects no more than 20 ft above the building height.

Municipal zoning may similarly affect construction of high towers or structures, which might be esthetically undesirable in residential or downtown areas. Rural sites have the advantage of local interest or pride in the station, and a nearby farmer is readily retained to check tower light daily and report outages to the CAA and contractor during the constrction period until tower light alarms are tied into the microwave fault indicating system.

Geography. In order to obtain maximum path lengths with minimum tower heights, sites should be selected to take advantage of terrain features or available structures. Sites may be located on prominent elevations (with access roads and available power) or on existing buildings. Often, one or more microwave or VHF radio facilities will already be located on such prominent sites. If there are no interference problems, the owners of existing facilities are generally receptive to sharing their property rights in return for cost-sharing on the lease or on any road improvements or power pulling that might have been required initially.

Even more practical than location of sites at prominent elevations is the selection of paths that provide low elevations over the broad middle portion

of the path. By shooting down a valley, between mountains, or over a low river bed in this fashion the effect of earth curvature is partially nullified, with resultant reduction of tower heights for a given clearance over the critical mid-path region.

In shooting over river beds or low valleys, however, full consideration should be given to the possible effect of frequent fog layers and resultant bending or ducting of the microwave beam. In shooting down a valley or through a saddle between mountains, the effect of lateral clearance as well as vertical clearance must be considered. The same Fresnel zone clearance is required in all directions, but the amount of beam bending is usually negligible in the lateral direction unless fog fronts roll up a valley at an angle with the beam direction.

Path Obstructions. Nearby obstructions may block the line-of-sight path to some desired communication points. For example, pump stations in mountainous country are located along low routes, whereas microwave sites are preferably located at high spots. If a tall tower at the pump station will not clear nearby hills that block the path, several alternatives are possible. The microwave station can be located on one of these nearby hills (with reasonable access and power pulling cost) and the link to the pump station can be established by a spur microwave hop or by land line. Alternately, a passive repeater can be located on the hill to "bend" the microwave beam around the obstruction so as to link the pump station and distant microwave site.

Passive repeaters may employ large "billboards" to reflect the beam, mirror-like, in a manner analogous to use of tower-top reflectors to bounce the beam from ground-level antennas at 6700 mc. The billboard site should be as close as possible to one station for practical size and cost, and the total path length is limited with present power levels. A practical installation involves a 20-ft by 30-ft billboard placed up to approximately one mile back from the near station on a 20-mile path.

Back-to-back parabolic dishes have been utilized recently as passive repeaters to bend the microwave beam at angles of 10 deg to more than 90 deg. This technique is more practical than use of billboards in many cases because of lower cost and ready adjustment. Total path lengths are limited as in the case of billboards, however. RF power amplifiers may be incorporated in the adjacent microwave transmitters to permit use of passive repeaters over long paths without sacrificing fade margin.

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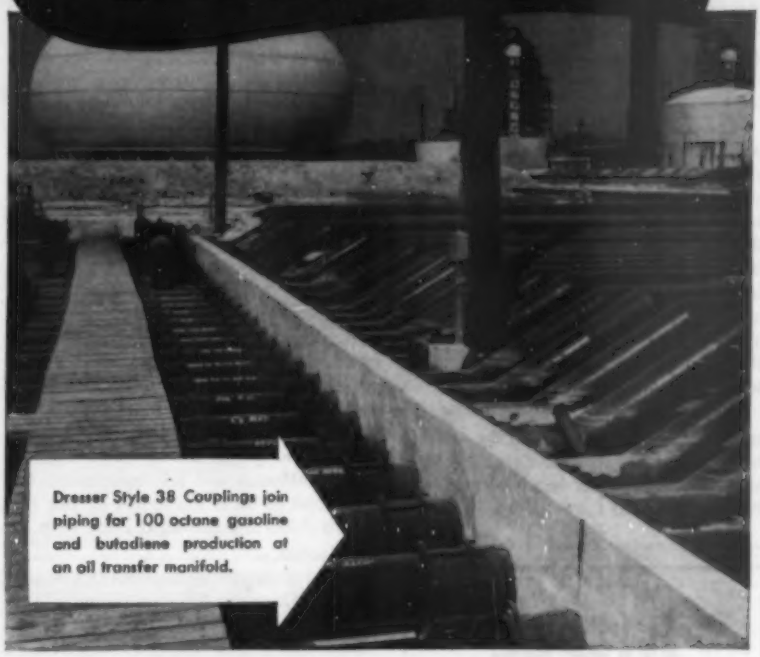

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The techniques and criteria for use of back-to-back dishes and billboards will be covered more fully and graphically depicted later in this series.

The same techniques may be utilized in circumventing a nearby building that obstructs the line-of-sight path from a downtown building-top site. For example, a standard 8-ft by 12-ft reflector is being used in an installation on top of the Commerce Building in Houston to deflect the beam around the nearby Gulf Building, which obstructed the path in a microwave system installed by Collins Radio Company for Industrial Gas and Supply Corporation.

The use of scatter propagation links is a practical solution for long obstructed paths when intermediate relay sites with good access and power are not available. Scatter links are based on the phenomenon of forward scattering of the radio energy in the atmosphere in the zone where the beam patterns of adjacent station cross. Scatter links are analogous to microwave operating in the "shadow" region below line-of-sight.

The higher loss of such non-line-of-sight paths is compensated by use of large dishes, higher power transmitters, and reduced receiver bandwidth to buy back the lost dbs for reliable communication. A typical tropospheric scatter link in series with a microwave system along a pipe line may utilize dual 28-ft dishes and 1-kw transmitters at 1000 mc to provide four voice circuits over a 160-mile path with 99.9 per cent reliability.

In selecting sites for tropospheric scatter links, two important considerations are the angle to the horizon and site elevation above sea level. The angle should be kept below one degree, and sites at high altitude will produce additional loss.

Separation of Equipment. Building-top installations often pose a problem in separating antenna, RF equipment, and multiplex. The antenna must be mounted with the path consideration uppermost. It is generally preferable to install the radio equipment near the antenna, but these may be separated by several hundred feet if necessary.

Long waveguide runs for separating antennas and RF racks can be employed in 6700-mc equipment utilizing recently-incorporated load isolators in the radio equipment; the loss in db is 1 db per 100 ft and the cost of waveguide runs is approximately $2 per ft plus installation cost. Coaxial cable can be employed at lower frequencies to link antennas and RF equipment, but the cost in db is 1.2 to 2.4 db per 100 ft at 2000 mc for rigid coax with air dielectric.

The multiplex equipment can be separated from the RF equipment by several thousand feet if necessary by using a pair of low cost, flexible coax lines to provide a video baseband connection. This connection method is frequently used in downtown building installations in which the multiplex equipment is situated near the PBX or in the communication room many floors below the RF site.

At way stations along a microwave route it may be desirable to connect into a land line either at audio or carrier frequencies. Audio terminations are used if the number of channels is low or consists of only a physical. Where a number of circuits are to be fed through, however, back-to-back audio connection of the wire line carrier and microwave carrier equipment is not desirable from a maintenance standpoint; the unnecessary drops decrease reliability and increase operating cost.

It is preferable to make a direct connection at the carrier frequencies, so that the channels are dropped only where needed. This technique can be used with low frequency single sideband channels directly on a 4-wire line or, with the addition of directional filters, on a 2-wire line.

The result of this microwave/wire line integration is effective separation of multiplex equipment from the microwave trunkline by distances usually employed in wire line carrier practice.

Alternate Sites. Alternate sites should always be selected to provide leeway for availability and cost of land. A right-of-way man or real estate purchaser should follow up on the survey by acquiring options on the selected sites or, when necessary, the alternates. Purchase of the final sites is preferable to long-term lease arrangements both legally and economically, as most microwave sites are engineered and installed for long-term occupancy.

Most drop communication sites will be on company property, and it is sometimes possible to locate through relays on pipe line or oil company property as an alternate to be considered in view of the possibility of future drop channel requirements at such property.

When a site selected would require a tower height in excess of 360 ft, an intermediate relay site should be selected as an alternate to reduce tower heights to more reasonable proportions. The two alternatives should be compared in initial cost, maintenance cost, and overall reliability to permit site selection in terms of both economics and system performance. ★ ★

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CURRENT COMPARISON OF COST INCREASES From 1950 Through 1955

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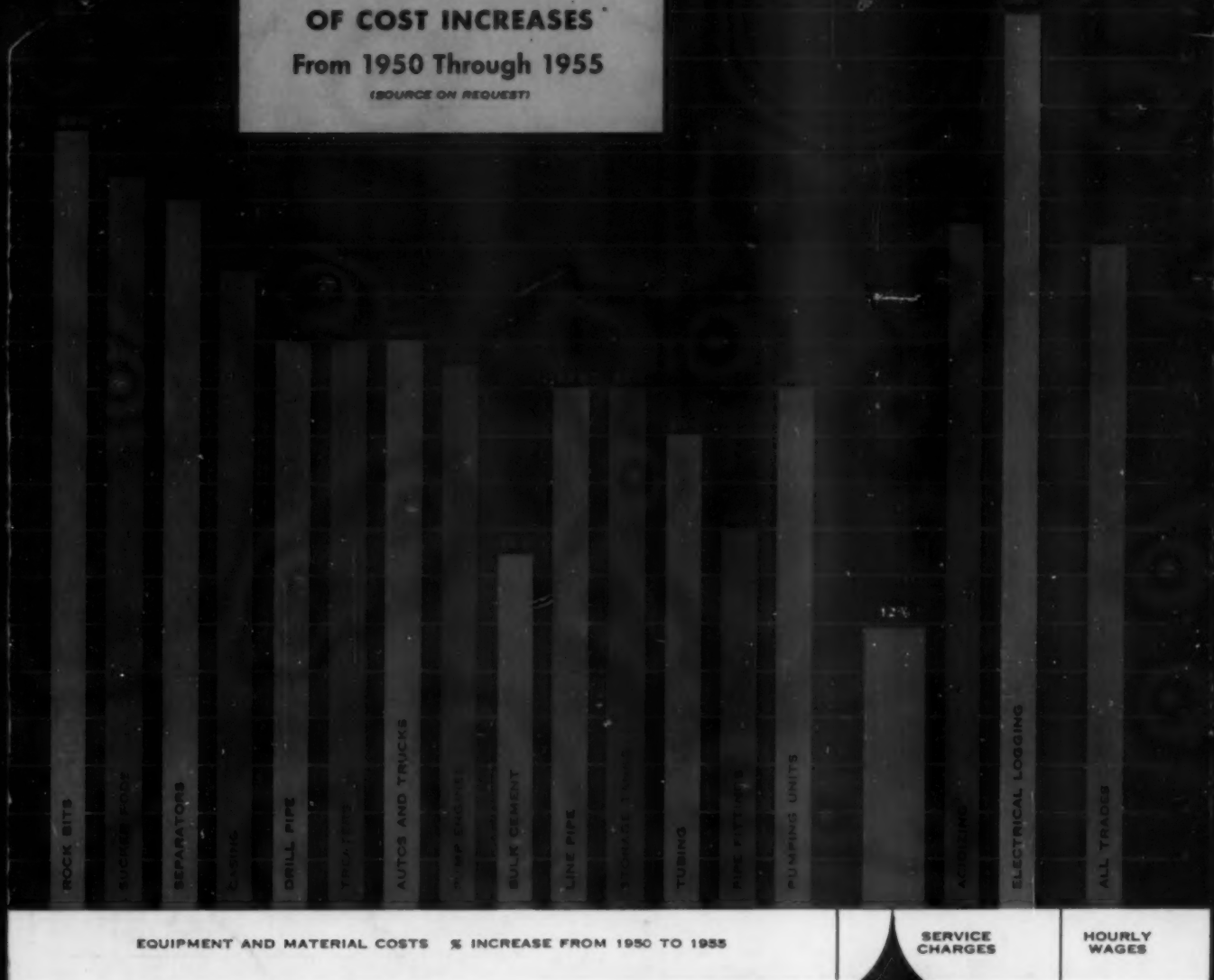

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